SUMMARY AND RESPONSE TO PUBLIC COMMENTS

Permit No:	Aquifer Protection Permit (APP) No. 511633, LTF 61397
Facility Name:	Gunnison Copper Project
Applicant:	Excelsior Mining Arizona, Inc.
Permit Action:	Response to comments received during the public comment period: June 14, 2017 to August 4, 2017
Prepared By:	Arizona Department of Environmental Quality (ADEQ) Groundwater Section 1110 W. Washington Street Phoenix, Arizona 85007
Date:	September 1, 2017

A. INTRODUCTION

Summary

The proposed project consists of an in-situ copper mine located on approximately 700 acres of land in Cochise County. The project is an in-situ leaching and recovery operation (ISR) using wells to inject and recover mining solutions. This process involves injecting leach solutions (lixiviant) into the orebody using injection wells and extracting copper-bearing solutions (pregnant leach solutions or PLS) through surrounding recovery wells. The lixiviant will be injected into the oxide zone of the bedrock beneath the site for the purposes of dissolving copper minerals from the ore body. The estimated injection zone is between approximately 250 feet below ground surface (ft bgs) to 1,500 ft bgs. The resulting copper-bearing solution will be pumped by recovery wells to the surface where copper will be removed from the solution in a solvent extraction electrowinning (SX/EW) plant. The barren solution from the SX/EW plant will be re-acidified and re-injected back into the oxide zone. The project will be constructed and operated in three stages.

Public Notice Comments

The public comment period began on June 14, 2017 and ended August 4, 2017. Publication of the preliminary decision to issue an individual APP and the associated public hearing was published in the Arizona Range News on July 5, 2017. This summary of public comments received and associated ADEQ responses is prepared in accordance with the Arizona Administrative Code (A.A.C.) R18-9-109.

Everyone who commented during the public comment period has the right to file an appeal and request a hearing on the final decision as an appealable agency action under A.R.S. § 41-1092.03 by filing a written Request for Hearing or Notice of Appeal within 30 days of issuance of the final decision. A Request for Hearing or Notice of Appeal is filed when it is received by ADEQ's Hearing Administrator as follows:

Hearing Administrator
Office of Administrative Counsel
Arizona Department of Environmental Quality
1110 W. Washington Street
Phoenix, AZ 85007

The Request for Hearing or Notice of Appeal shall identify the party, the party's address, the agency and the action being appealed and shall contain a concise statement of the reasons for the appeal. Upon proper filing of a Request for Hearing or Notice of Appeal, ADEQ will serve a Notice of Hearing on all parties to the appeal. If you file a timely Request for Hearing or Notice of Appeal you have a right to request an informal settlement conference with ADEQ under A.R.S. § 41-1092.06. This request must be made in writing no later than 20 days before a scheduled hearing and must be filed with the Hearing Administrator at the above address.

Comments received during the public comment period are summarized below. The comments are followed by ADEQ's response shown in *italics*. Comments are organized as follows:

Commenter #	Source	Method
1	Anneke Mayer	Written
2	Thomas E. Sheridan	Written
3	David Yetman	Written
4	John Miller	Written
5	Pete Dronkers	Written
6	Dr. Tom Myers	Written

Comments may have been shortened or paraphrased for presentation in this document; a copy of the unabridged comments is available upon written request from the ADEQ Records Center, recordscenter@azdeq.gov.

B. DESCRIPTION OF DRAFT CHANGES TO THE PERMIT

A number of typographic errors were corrected and clarifying language edits made in the amended permit that are not reviewed in detail here. Substantive changes to the permit include:

1. Addition of a reporting requirement for periodic groundwater modeling evaluation and updates in Section 2.7.4.8 and Section 3.0

C. WRITTEN COMMENTS

Written comments received on the official record were received during the Public Comment period.

#1, Anneke Mayer: The commenter submitted the following email on July 12, 2017.

I live 2 or 3 miles as the crow flies from the proposed Gunnison copper mine and am very concerned about any new use of water beyond commitments already in place. Our local water table is getting lower and lower and although the process Gunnison plans to use does sound like a safer way to get copper out of the ground than traditional methods, it still will use water that people already living here need to be able to stay in their homes.

One of the arguments the mine people make to justify their use of the water is that it's much less than local Ag uses. But it's still more drain on the limited supply and to add a new demand is irresponsible to everyone except maybe the people hoping to make a profit off the enterprise. Who aren't Arizonans.

I request that you deny the DEQ permit on the basis that drying up the environment definitely decreases its quality.

> ***ADEQ response to Comment #1***
> *The Aquifer Protection Permit (APP) Program is tasked with protecting Arizona's groundwater quality. The program does not regulate water quantity. The ADEQ APP will protect the groundwater supply by assuring that groundwater leaving the mine site will not exceed Arizona's Aquifer Water Quality Standards (AWQS), or pre-operational levels, if the AWQS are exceeded in groundwater prior to mining.*

#2, Thomas E. Sheridan: The commenter submitted the following email on July 21, 2017.

I want to express my concerns about Excelsior's Gunnison Copper Project in Cochise County. As an anthropologist who has studied the peoples of the Southwest and Northern Mexico for more than forty years, and as author of Arizona: A History (University of Arizona Press 2012), I know that nothing is more important to the long-term sustainability of human society in Arizona than its water supply. That water supply is extremely limited. Surface water from the Colorado River and its tributaries is already over-allocated, and will become even scarcer as the region grows hotter and drier because of global climate change. Arizona's groundwater aquifers are essentially finite resources that are being pumped at levels that exceed natural recharge in many areas of the state.

Arizona statesmen recognized that fundamental reality when they passed the Groundwater Management Act in 1982. And even though Cochise County is not in one of the state's Active Management Areas (AMAs), its groundwater resources need careful stewardship or its economy based on tourism and agriculture will wither and die. The Arizona Department of Environmental Quality is the agency mandated to carry out that stewardship through its permitting responsibilities and through the long-term monitoring that must be conducted over the life of endeavors like the Gunnison Copper Project.

The in situ injection process that Excelsior proposes to utilize for the Gunnison Copper Project is a novel and potentially dangerous process, one that requires stringent monitoring to insure that absolutely no pollutants escape its hydraulic control areas. The project is immediately uphill from the community of Dragoon. It is also adjacent to the Amerind Foundation, one of Cochise County and Arizona's most important cultural institutions. Both the community of Dragoon and the Amerind draw their water from wells downhill from the Gunnison Copper Project. Contamination of their common aquifer could be catastrophic for hundreds of residents in Dragoon who rely on that aquifer for their drinking water.

It could also be a devastating blow to the Amerind, which attracts at least 12,000 visitors a year and hosts numerous public events, research seminars, and Native American and Western arts shows. Moreover, if any of the millions of gallons of sulfuric acid injected into the Gunnison's Copper Project's wells each day were to infiltrate into the Sulphur Springs Valley, Cochise County's most important industry – agriculture – could be threatened as well.

To avoid such potentially disastrous consequences, the following steps should and must be followed:

1) The aquifer needs to be treated as a pristine source of water that should not be degraded to any extent. To insure against its degradation, Excelsior should pay for baseline studies of a robust representative sample of municipal, agricultural, and residential wells outside as well as inside its hydraulic control areas. Excelsior should then pay for quarterly testing of that representative sample of wells so that any pollutants are quickly identified.

   ADEQ response to Comment #2.1
   ADEQ takes the comments and concerns of the nearby community member's serviously. However, ADEQ does not have the authority to require a permittee to pay for monitoring of privately owned wells downgradient of the point of compliance (POC) wells. The Department has thoroughly considered the ways in which fluids can escape from the injection activity and has concluded that the Aquifer Protection Permit (APP) meet all statutory and regulatory requirements and includes robust monitoring which allows us to understand the current status of the aquifer and alert the agency to any degredation caused by the project. The APP requires the permittee to conduct ambient groundwater monitoring of point of compliance (POC) wells located at the edge of the pollutant management area (PMA), Intermediate Monitoring Wells (IMW) located within the PMA, and Observation Wells (OW) located in the vicinity of Hydraulic Control Wells (HCW) located at the edge of the in-situ well field. Excelisior is also required to monitor within the PMA (in the IMWs) to monitor the performance of the in-situ leaching and recovery system, and monitoring of POC wells to ensure compliance with the permit.

2) If levels of pollutants rise, and if the pH of the groundwater declines and becomes even slightly more acidic, the process of injecting sulfuric acid into Excelsior's injection wells needs to stop immediately and completely. The process must not be allowed to resume until the source of pollution is identified and the water quality of the representative sample of test wells outside the hydraulic control areas returns to baseline status, no matter how long that takes.

   ADEQ response to Comment #2.2
   The APP contains contingency actions that requires Excelsior to mitigate any potential excursions from each active mine block. The inner and outer ring of IMWs are located

and are screened within the major structural features (faults) as shown on Figure 2-9 Intermediate Monitoring Well Locations – Cross Sections E-F (See ADEQ Reference Figures at the end of the Responsivness Summary). The inner and outer ring of IMWs are monitored daily for specific conductance, a parameter that can move at the same velocity of groundwater and is used as a precursor for other constituents. If specific conductance rises in the outer ring of IMWs, Excelsior is required to evaluate the cause, increase pumping rates at the mining block recovery wells, or add or turn on additional hydraulic control wells with their associated observation wells.

3) Monitoring should be conducted by a disinterested third party at Excelsior's expense, and not just by Excelsior, to insure that the water quality of the aquifer in question remains at baseline quality for the entire length of the Gunnison Copper Project or its successors. Transparency and accountability have to be built into the process for as long as the mine continues to operate.

ADEQ response to Comment #2.3
The APP program is a self-reporting program. The permit requires Excelsior to conduct sampling and analysis at all monitoring points and to report the results to ADEQ. As discussed above in ADEQ Response to Comment #2.2, exceedances or excursions from permit conditions will require Excelsior to investigate and take appropriate corrective actions. In addition, regardless of who owns the facility, monitoring is required to continue until closure is completed and ADEQ is satisfied any potential environmental impact has been mitigated.

If ADEQ has reason to believe that conditions in the permit are or have been violated, ADEQ will investigate and take any necessary enforcement action

Even slight changes in acidity could require extremely costly remediation measures that could exceed the financial capacity of surrounding residents, businesses, and institutions like the Amerind. A single enterprise like Excelsior's Gunnison Copper Project must not be allowed to jeopardize an entire region's economy and quality of life. If Excelsior is allowed to proceed, it must be held to the stringent standards outlined above. The future of Dragoon, and Arizona, must not be sacrificed for short-term gain.

ADEQ response to Comment #2.4
The Department has thoroughly considered the ways in which fluids may escape from injection and recovery activities in the mine blocks and has concluded that the requirements of the APP meet all statutory and regulatory requirements to protect the aquifer and to ensure acidic fluids will not escape the well field. At the end of mining, the permit requires Excelsior to ensure that rinsing operations will neutralize acidic fluids and restore the aquifer to AWQS, or pre-operational background levels, if those exceed AWQSs, before closure of the site is approved.

#3, David Yetman: The commenter submitted the following letter via email on July 28, 2017.

I have been a resident of Greenlee, Cochise, and Pima Counties for six decades. I am familiar with ongoing problems of water supply, the creation of Arizona's groundwater pumping regulations, and the variability of water quality between basins and as affected by industries. I cite the contamination of wells by trichloroethylene industrial solvents in the southern Tucson well field in the mid-1980s as an example.

From what I have seen of Excelsior's hydrological studies, they express no particular concern about the effects of their project on long-term water supplies or on water quality. Although published articles state that Excelsior plans to recover all injected sulfuric acid, its own documents appear to suggest that it will rely heavily on the neutralizing properties of Paleozoic limestone in the Gunnison Hills. My reading suggests that Gunnison's reports and projections are largely speculative. The actual effects of injected acid on the aquifers appear to be unknown and test well data have been inconclusive. The long-term effects on the Willcox Aquifer of their water extraction are, I believe, understated. The removal of such volumes of water over two decades also raises concerns about land subsidence that must be addressed.

ADEQ response to Comment #3.1
The fact that the ore body is within a limestone formation serves as a site specific characteristic related to neutralizing the acidic solutions used in mining. The Aquifer Protection Permit (APP) requires Excelsior to rinse the areas mined until acidic solutions are neutralized, regardless of the efficacity of the limestone. The APP requires the permittee to conduct compliance groundwater monitoring, both within the pollutant management area (PMA) (in the Intermediate Monitoring Wells (IMWs) and Observation Wells) and outside the PMA at the Point of Compliance (POC) wells to monitor the performance of the in-situ leaching and recovery system to ensure compliance with the permit. Subsidence is unlikely to occur as the basin fill is primarily unsaturated and all pumping will occur within the bedrock aquifer, which is not compressible.

The quantities of copper to be extracted suggest that huge amounts of water will be extracted from the Willcox Aquifer for the injection process and related operations and large volumes of sulfuric acid will be injected in recovering the in situ copper. Both of these factors should pose red flags for anyone issuing water permits. Parts of the Sulphur Springs Valley have already experienced dramatic declines in groundwater levels, and the neighboring community of Dragoon is entirely dependent on the Willcox Aquifer for its water supply and the recharge of that aquifer is either negligible or nonexistent. Without detailed geological analysis of the limestones, faults, and yet undetected thrust belts, reliance on chemical properties of naturally occurring geological formations is risky, indeed and water supplies are questionable. Furthermore, the storage of huge volumes of sulfuric acid near Interstate Ten and the Dragoon community raises deep concerns about escaped toxic chemicals.

ADEQ response to Comment #3.2
As discussed above in ADEQ Response to Comment #1, the APP program protects groundwater quality, but does not regulate groundwater quantity. The location of the ore deposit is within the bedrock aquifer and is located west of the Willcox Aquifer. The mine is not anticipated to have an impact to the basin fill Willcox Aquifer due to the long travel times (greater than 23 years) from the mine blocks to the POC wells. Sulfuric acid transportation, storage and handling is not under the perview of the APP program.

While I assume that these considerations are familiar to you, I call upon the Arizona Department of Environmental Quality to require that Excelsior fund independent hydrological studies of both the long-term effect on regional and basin-wide water supply and on long-term water quality effects of their operations over the life of their project and well beyond. Independence of the consulting geologists is essential. Experts paid directly by such companies have an uncanny tendency to produce results favorable to their clients.

ADEQ response to Comment #3.3
A hydrogeologic study was conducted by Excelsior which satisfies the requirements of the APP program per Arizona Administrative Code (A.A.C.) R18-9-A202(A)(8). As part of the hydrogeologic study, Excelsior was required to demonstrate that the aquifer would be protected. This is done by demonstrating that an AWQS would not be exceeded at a POC located on the downgradient boundary of the PMA. Also, as noted in ADEQ Response to Comment #1, the APP program does not regulate water quantity.

#4, John Miller: The commenter submitted an email on August 3, 2017 with the following comment.

Thank you for the opportunity to comment on the APP for the Gunnison mine.

In-situ acid mining has been around for ages and has yet to produce results without polluting the ground water.
With a 100% failure rate I would hope that the ADEQ director rejects this permit.

This mine has the potential to devastate the water supply and the quality of life for Dragoon Arizona residents.

Please stop this project from becoming reality.

ADEQ response to Comment #4
As stated in ADEQ's response to Comment #1, the Aquifer Protection Permit (APP) will protect the groundwater supply by assuring that groundwater leaving the mine site will not exceed Arizona's Aquifer Water Quality Standards (AWQS), or pre-operational levels, if the AWQS are exceeded in groundwater prior to mining.

#5, Pete Dronkers: The commenter submitted an email on August 2, 2017. The email contained comments submitted by Pete Dronkers on behalf of Dragoon Conservation Alliance Earthworks, Amerind Foundation, Arizona Mining Reform Coalition, and Patagonia Area Resource Alliance.

Introduction:

We have been studying this project closely for the last several years because it would utilize a largely untested technology for copper production, and carries the potential to contaminate groundwater on which multiple communities and businesses rely.

We are aware of no operating commercial copper in situ leaching (ISL) projects at greenfields sites anywhere in the United States that would provide references for their environmental performance. The Florence Copper Project in Arizona is perhaps the only comparable project, yet it has never been in commercial production and has been plagued by civic appeals to deny issuance of revised state and federal permits. At this point, it appears that the Gunnison Copper Project is on a faster path towards potential development, and therefore, is of great interest to environmental advocacy organizations both locally and nationally.

While copper ISL has been utilized on an experimental basis at existing hard rock mines, site conditions and engineering designs at those projects are so vastly different that forming useful environmental comparisons to a greenfield project is not realistic. Additionally, the Gunnison Project is much larger than prior brownfields experiments; acid injection would be over 7 million gallons per day during full production, injected directly into an aquifer of drinking water quality and relied upon by the town of Dragoon and surrounding outlying residential and commercial properties that have water wells. Conceptual flow models of the project area and downgradient of it indicate that existing water wells could be permanently compromised in a contamination scenario.

This includes the town of Dragoon's municipal supply well and the Amerind Foundation's wells. Amerind, located in Texas Canyon, is totally dependent on two wells near Dragoon's municipal supply well and pumped to the Foundation's facilities. Contaminated groundwater would threaten most of Dragoon's residents and businesses, as well as Amerind's existence and impact its ability to perform its role in protecting Arizona's cultural heritage. The Amerind Foundation is an active research and educational center for thousands of Arizonans, preserving thousands of irreplaceable archeological artifacts in its museum. Additionally, Native Americans across the US value Amerind's significant collection of contemporary Native American cultural objects and artworks and their ongoing preservation at Amerind's facility.

In prior conversations, Excelsior's leadership has suggested that the type of ISL design they intend to use is "off the shelf" technology. Presumably they were referring to ISL as it relates to numerous existing uranium ISL operations, such as those in Wyoming or Texas. They suggested that while the injection/recovery well configuration is different from what they intend to deploy at Gunnison, the technology is essentially the same. Earthworks and other groups have studied these operations as well and have been unable to find a single case in which uranium ISL operations have *not* resulted in groundwater contamination. A study published by the U.S. Geological Survey in 2009 found that *"To date, no remediation of an ISR operation in the United States has successfully returned the aquifer to baseline conditions."*[1]

For years, Excelsior has been explaining to the public that their operation is different in terms of environmental risk, yet at the same time suggesting that their technological approach is the same as the uranium industry's. This is the same technology that has caused

[1] http://www-pub.iaea.org/mtcd/meetings/PDFplus/2009/cn175/URAM2009/Session%204/08_56_Otton_USA.pdf

groundwater degradation in every commercial application to which it has been applied in the United States, and likely in the world.[2] In fact, some studies have suggested that groundwater quality continues to decline even after post-mining groundwater rinsing has been completed.

Monitoring:

We understand that the Gunnison project is upgradient of a limestone formation that may help neutralize contaminants that follow the flow pathway, but this is akin to suggesting that a driver cannot possibly crash because all the passengers are wearing seatbelts. This puts the environmental burden on the effectiveness of Excelsior's hydraulic control methods, but more importantly, on the point of compliance (POC) wells beyond the area of hydraulic control.

ADEQ's draft Aquifer Protection Permit (APP) is inadequate to effectively detect potential contaminant migration for many reasons articulated in these comments, but primarily because there are simply not enough POC wells, and there is not sufficient modelling to best determine their placement. We ask that ADEQ vastly increase the number of POC wells from five to at least 25 (not including the liquids impoundment POC wells), and that these wells be drilled not simply on the boundary of the project area (Pollutant Management Area boundary) but over a much broader area extending further from the project site, predominantly within the conceptual flow model pathway, but also in opposite directions. The locations of these additional wells should be according to the additional work these comments address; their placement is best determined through proper modelling that uses a higher resolution, better calibration, and results in a unique model. Some of these POC wells may be a significant distance from the site and may be owned by a different property owner. In such a case, ADEQ and Excelsior should do everything possible to ensure leasing arrangements or memorandums of understanding between the company and the landowner where these wells may be cited.

ADEQ response to Comment #5.1
ADEQ does not agree that the required monitoring is inadequate. The Aquifer Protection Permit (APP) for this project requires extensive monitoring within the Pollutant Management Area (PMA) (Intermediate Monitoring Wells (IMWs) near the mine blocks, and Observation Wells (OWs) between the Hydraulic Control Wells (HCWs) and the Point of Compliance (POC) wells), includes extensive pre-operational requirements, including, but not limited to, conducting at least four aquifer tests within Mine Block 1, conducting ambient groundwater monitoring in each mine block, 19 Outer IMWs, seven OWs, seven HCWs, and three POC wells, and establishing hydraulic control prior to any injection (Section 2.2.3 of the APP).

ADEQ does not agree that the request for additional POC wells at this time is warranted. Based upon the information that has been collected to date, the estimated travel times to the currently proposed POC well locations is several years, any further

[2] http://www.wise-uranium.org/uisl.html

distant POC wells would have much larger travel times and would not indicate a problem at the mine.

In response to the comments relating to additional groundwater modeling, ADEQ does not agree that additional groundwater modeling should be conducted at this time.

ADEQ agrees that periodic updates and evaluation of the groundwater model should occur during mining and mine closure. ADEQ has revised Section 2.7.4.8 and Section 3.0 of the permit to include periodic groundwater model evaluation and update reports, beginning after completion of the first year of operation for each of the three stages of mining and every 5 years thereafter for mining Stages 1 and 3 until mine closure.

Additional POC wells should be placed where contaminants would be most likely to migrate based on this additional modelling work. During the first year of commercial production, monitoring of all POC wells is requested monthly; in the second year, bi-monthly; in the third year, quarterly, and so on until year five. After that, biannual monitoring is acceptable. All POC wells should be drilled at least one year prior to commercial operation, and extensive baseline water quality data should be collected by a third party laboratory for all of them and posted online. Baseline data should include every known constituent of concern that could degrade groundwater quality in any way.

ADEQ response to Comment #5.2
ADEQ does not agree with the proposed frequency of POC well monitoring proposed by the commentator. As stated in ADEQ response to Comment 5.1, travel times for constituents in the groundwater are years. The constituents that are monitored quarterly are those constituents that are highly mobile, and is sufficient to provide adequate monitoring. Within the PMA, specific conductance must be monitored daily, which provides a much faster evaluation on how the system is working and allows for quick responses should excursions occur. Please refer to ADEQ response to Comment #2.1 regarding the comment pertaining to third party sampling.

We also ask ADEQ, as a condition of approval of the APP permit, to include mandatory biannual monitoring requirements of existing wells on private property for those who request it. ADEQ should consider at least a five mile radius to determine who is eligible for this program. In addition, ADEQ should require that abandoned wells within a five mile radius be inspected and analyzed by a third party to ensure that vertical mixing of contaminants from one potential pathway to another doesn't exacerbate the spread of pollutants in a contamination scenario. If this is determined to pose any risk, ADEQ should require the complete plugging of these wells.

ADEQ response to Comment #5.3
The APP requires the permittee to conduct compliance groundwater monitoring within the PMA (in the IMWs) to monitor the performance of the in-situ leaching and recovery system. Exclesior must also monitor POC wells at the edge of the PMA to ensure compliance with the permit. ADEQ has determined that there is not a need to require Excelsior to sample existing wells on private properties within five miles of the site due

to the long travel times (greater than 23 years) from the mine blocks to the POC wells. Please refer to ADEQ response to Comment #2.1 regarding the comment pertaining to third party sampling.

Given the extraordinary environmental and social impact of a groundwater contamination scenario beyond the area of hydraulic control, and the historical context of the poor environmental performance of ISL technology generally, Excelsior and ADEQ must demonstrate that they are committed to the preservation of baseline water quality. The company seems quite confident that its operations will not compromise water quality. If this is to be taken seriously, then ADEQ should impose strict conditions of approval regarding what happens when things do not go as planned, and Excelsior should have no problem agreeing to such conditions, which are addressed below.

ADEQ response to Comment #5.4
The APP imposes specific contingency actions should alert levels be triggered which may include, but is not limited to, continued monitoring, adjusting operations in the mine block(s) to pull back solutions, adjusting pumping rates in the appropriate Hydraulic Control Wells and/or installing and begining pumping from additional interceptor Hydraulic Control Wells if they are not already installed. These and other contingency actions, should alert levels be triggered, are protective of the aquifer..

Corrective actions as conditions of approval:

At all POC wells, including the additional ones requested in these comments, a third party laboratory shall collect and analyze data on the frequency requested above. Any detectable change beyond the alert limit at POC wells shall be noted and the findings published online. ADEQ, Excelsior, and all interested civic groups shall meet immediately if and when this occurs to discuss the specific nature of the baseline deviation, and what may be the cause of it. If the exceedance continues for six months, Excelsior must cease all injection operations, or, if the problem appears to be local and specific to POC wells next to liquids storage facilities, those facilities shall be drained and repaired immediately. If specific conductivity or pH exceed alert levels at the intermediate monitoring wells or at the observation wells, similar responses are necessary because these parameters are indicators of problems. Specific conductivity and pH should immediately begin to be monitored at the POC wells downgradient of the intermediate wells with exceedances.

If any analytes exceed state and/or federal maximum contaminant levels for groundwater that were not already exceeded in the baselines, Excelsior must cease all injection operations immediately, or as noted above, drain liquids impoundments and repair the leak(s). During this cessation period, ADEQ, Excelsior, and civic groups shall convene to attempt to reach consensus about the cause of the exceedances and produce a plan for immediate corrective actions. Once the corrective action plan is created and implemented, injection of lixiviant (or utilization of liquids impoundments) shall not continue until the affected POC wells return to baseline. If conditions fail to return to baseline or continue to worsen, rinsing operations shall begin per the APP permit procedures, and Excelsior shall not be permitted to stop rinsing or continue reinjection until conditions have returned to baseline.

ADEQ response to Comment #5.5

The APP contains contingency actions (Please see all subsections under Section 2.6) that Excelsior is required to take if there is an exceedance for a BADCT condition (both for ponds and for the well field) or violation of the permit such as an exceedance of an Aquifer Quality Limit (AQL) at a POC well. In such a situation, Excelsior is required to notify ADEQ and provide appropriate documentation of corrective action. In addition, ADEQ conducts periodic inspections to ensure the mine is in compliance with the permit. Please refer to ADEQ response to Comment #2.1 regarding the comment pertaining to third party sampling.

Bonding:

Bonding levels have not yet been determined by ADEQ, but it is critical that bonding amounts consider groundwater contamination, not simply planned reclamation bonding for rinsing, well pad reclamation, the removal of outbuildings, and other similar planned activities. State bonds must account for all possible environmental liabilities, including a worst-case scenario calculation and the costs associated with all elements of the resulting cleanup.

As you may know, pending federal bonding regulations under the Comprehensive Environmental, Reclamation, and Liabilities Act (CERLCA), section 108(b), are not guaranteed to address these issues at this time. It remains to be seen what the final regulations will or will not cover. Therefore, the state of Arizona must hold bonds that the EPA regulations may not cover if the project begins operating. The bond would provide specific calculations for the costs associated with a large contamination event which spreads rapidly and must be remediated immediately. It should also include calculations for catastrophic liquids impoundments failures due to overtopping, impoundment breaches, or major liner failures. In the event that EPA regulations do cover many of these items, a memorandum of understanding between ADEQ and EPA should specify which agency will bond for specific potential failures.

Most importantly, ADEQ must not allow corporate guarantees from Excelsior or any subsequent operator to qualify as bonds. Bonds must be actual financial assets, not legal promises or certificates of financial health or credit worthiness.

Finally, the process of bonding the Gunnison Copper Project should use a stakeholder-based approach, publicly noticed, and put out for a 60 day scoping comment period. ADEQ should prepare a draft bonding proposal using input gathered during the public scoping process, and release a draft bonding proposal for another 60 day public review period.

ADEQ response to Comment #5.6
The APP includes a compliance schedule item (Section 3 of the permit) which requires the permittee to submit the financial assurance mechanism under an amendment to the APP. By law, the cost estimate must include the cost of mitigating any excursions, closure of APP regulated facilities, and post-closure monitoring. Also by law, all APP applicants are allowed to use any of the financial assurance mechanisms listed under A.A.C. R18-9-A203(C).

Technical comments:

For this review of the Draft Aquifer Protection Permit, we have consulted with an independent hydrologist, Dr. Tom Myers, for a full review of the technical and modelling components ofthe project. Dr. Myers has been involved with this project for over two years, has written a preliminary conceptual flow model, has reviewed Excelsior's APP application and all appendices, and has reviewed the draft APP from ADEQ to produce the attached analysis. Dr. Myers has also visited the Excelsior site and met with Excelsior leadership to discuss project specifics in person.

The undersigned organizations include by reference Dr. Myers' technical comments included in this transmission as a PDF file. The technical comments should receive the same consideration as this document.

We appreciate the opportunity to submit these comments, and hope they will result in important technical changes as well as conditions of approval to the draft APP.

ADEQ response to Comment #5.7
Responses to Dr. Tom Myers comments are provided below.

#6. Dr. Tom Myers, Consultant: The email from Mr. Dronkers also contained comments prepared by Dr. Tom Myers, an independent hydrologist and consultant for Dragoon Conservation Alliance Earthworks, Amerind Foundation, Arizona Mining Reform Coalition, and Patagonia Area Resource Alliance.

Summary and Conclusions

Excelsior Mining Arizona proposes to construct an in-situ leach and recovery copper mine near Dragoon, Arizona. This technical memorandum reviews the Aquifer Protection Permit Application for the Gunnison Copper Project.

The regional aquifer under consideration extends from the Little Dragoon Mountains in the west to the Gunnison Hills in the east and Dragoon Mountains on the south. Groundwater generally flows from recharge areas near the Little Dragoon Mountains and within ephemeral channels in the west almost directly eastward across the site to gaps in the mountains north and south of the Gunnison Hills. Groundwater would flow through these gaps eastward to the broader Willcox Valley.

The aquifer properties are highly heterogeneous and oriented according to the dip of faults and fracturing that occurs naturally in the area. However, the analysis presented in the APP application averages the hydrologic properties so that heterogeneity is not well considered and the importance of preferential flow paths is minimized. Fracture intensity and porosity modeling shows substantial variability that the application tends to present as averages. Even though the pump tests indicate that properties vary by direction, with a tendency for the northwest to southeast direction to have higher conductivity, the analysis in the application does not account for this. Averaging and failure to consider directional differences causes the application to not adequately consider preferential flow paths caused by fracturing and through which much more groundwater, and injected fluid, would flow.

The project is an in-situ leach and recovery project for copper (Cu) in the bedrock formations underlying the basin fill at the site. The project involves injecting an acid solution into the groundwater of the bedrock aquifers so that it can leach Cu which would then be recovered in capture or collection wells. The well layout would have four collection wells surrounding each injection well, but a map of the pattern suggests that each collection well would be part ofthe four collection wells surrounding other injection wells. The injection rate would vary with time throughout the project life, with the total injection ranging from 5300 to 25,600 gallons per minute with the lower rate for the first ten years. The injection/collection process would collect more water than is injected, which should cause a general groundwater level drawdown within the well field. A line of collection wells would surround the well field and be designed to withdraw water and create a trough in the potentiometric surface intended to prevent fluid from escaping from the wellfield. Predicted drawdown from hydraulic control wells would extend to the east of the well field by 1200 to 1500 feet from the control wells at maximum pumping based on modeling. There is no guarantee that these wells would intercept flow in each preferential flow path, due to the heterogeneities described above.

The processing of copper would allow most other metals to remain in solution, and be circulated back through the system, so that the water would have concentrations of metals and some anions that are multiple times their water quality standards. Concentrations of cadmium, lead, selenium, nickel, thallium, zinc, and fluoride, among others, would be orders of magnitude higher than background levels and most water quality standards. The incredibly poor water quality of the leach solution exemplifies why preventing any of it escaping the system is critical.

The application argues this site is favorable for "maintaining control of the leach solution" because there is limestone within and downgradient of the wellfield, which would provide a large attenuation and neutralizing capacity. The claim regarding downgradient attenuating formations is too broad because there has been no consideration of the amount of neutralizing carbonate rock that would actually contact any acid escaping the well field. If escaping acidic fluid flows through preferential pathways so that only a small portion of limestone iscontacted, some may escape unattenuated. The limestone should not be relied on to neutralize acid that reaches it, unless there is an accounting for the effective neutralizing capacity of in situ limestone.

Groundwater model simulation of the ISL project is too coarse, meaning completed without sufficient detail, and too unrealistic, to provide much confidence in the results. Only the hydraulic control wells were simulated. The ISL system was simulated by simply placing contaminant particles in the model at the edge of the interior wells fields, but not under pressure as they will be during operations. High injection rates and heterogeneities in the well field could easily cause flow paths not captured by collection wells. Without simulating the injection/collection wells, this model does not provide reliable information regarding theeffect of the injection/recovery system on local or regional flowpaths.

The model is too coarse because the pathways are, at a minimum, 50-feet wide (model cell sizes) which means the hydrologic properties are averaged over an area that wide. It completely misses the potential narrow pathways that could preferentially allow particles to exit the system. Simulation of mining should be improved by simulating the actual injection/recovery wells, with injection rates depending on the localized conductivity and pressures that would be acceptable for operations. The model should be discretized into much smaller cells at the mine so that injection/recovery can be simulated more accurately. The geology/fracture intensity model should be used at a smaller scale to provide more detail of flow paths through the well field.

There are far too few point of compliance (POC) wells and the design could allow contaminant plumes to escape the well field undetected. The POC wells also have screens, or open intervals, that are far too wide that will allow the contaminants to be diluted by clean flow either above or below the pathway transporting the contaminants. POC wells should be redesigned according to results from modeling dispersion with the more-detailed model. The POC wells should have multiple screens so that individual productive flow zones can be sampled without dilution from above or below.

The following sections provide much more detail regarding the application, and the factors of it that should be improved to make the APP application more protective of the environment. This is especially true for the groundwater modeling and the POCwells.

Introduction

This technical memorandum is a review of the Aquifer Protection Permit Application for the

Gunnison Copper Project proposed by Excelsior Mining Arizona (CCA 2016). Clear Creek Associates attached several other studies to the application that were also reviewed herein. These included the Aquifer Testing Report (Appendix G) and the Groundwater Modeling Report (Appendix I). Other appendices contained data and other information that supported the application or Appendix I, including a Hydrology Investigation Well As-Built Diagrams (App C), Hydrogeological Well Completion Report (App F), Geophysical Logs (App H), and Fracture Gradient Testing and Analysis (App N). References within this review are to CCA (2016) or to the various appendices.

Regional Hydrogeology

Surface formations at the site and around the valley from the Little Dragoon Mountains to the Gunnison Hills are basin fill except near the mountains where there are bedrock outcrops. Basin fill is generally eroded material from nearby mountains that has settled into a valley and has been minimally sorted by rivers and streams. The basin fill near the wellfield is saturated only in one area near the project site. East of the project site and near Dragoon, the basin fill approaches 1000 feet in thickness in a deep north-south trending trough.

Groundwater generally flows from recharge areas near the Little Dragoon Mountains and within ephemeral channels on the west side of the valley through bedrock to deep basin fill almost directly eastward across the site. Groundwater recharge is precipitation that percolates through the soil and rock to reach the groundwater table. Depth to water ranges from 244 to 655 feet, with most water levels below the top of bedrock except for a north-south swath across the western third of the site where the water levels indicate the aquifer is confined (CCA 2016, p 5-9). Confined aquifers are those in which the water pressure causes water level in the wells to rise above the top of the aquifer, the confining layer that separates the aquifer from overlying formations.

Groundwater flowing in bedrock fractures to the east would reach the basin fill in the deep trough east of the site. Groundwater likely discharges to saturated fill in the deep trough. Residence time, or the average time for water to cycle through the aquifer, in the fill is likely very long, on the order of at least centuries if there is mixing. If mixing is limited, the residence time for some of the water could be much shorter. East of the wellfield, groundwater either flows south to a gap between the Gunnison Hills and Dragoon Mountains or north of the Gunnison Hills.

The regional potentiometric surface slopes steeply east until reaching the saturated basin fill east of the project site where the slope flattens greatly (Figure 1). Flow in the bedrock is mostly east toward the saturated basin fill. In the fill, the slope is much flatter but to the south and the discharge point east to the Willcox Playa area. Hydraulic gradient, slope measured in feet per foot, is significantly flatter through the area of the deposit, about 0.01 or lower than in bedrock to the west (CCA 2016, p 5-11). The application claims it is due to more fracturing and higher permeability associated with skarn mineralization but the gradient flattening could also be due to flatter topography and structures downgradient, such as impervious faults on the west face of the Gunnison Hills damming or diverting the flow.

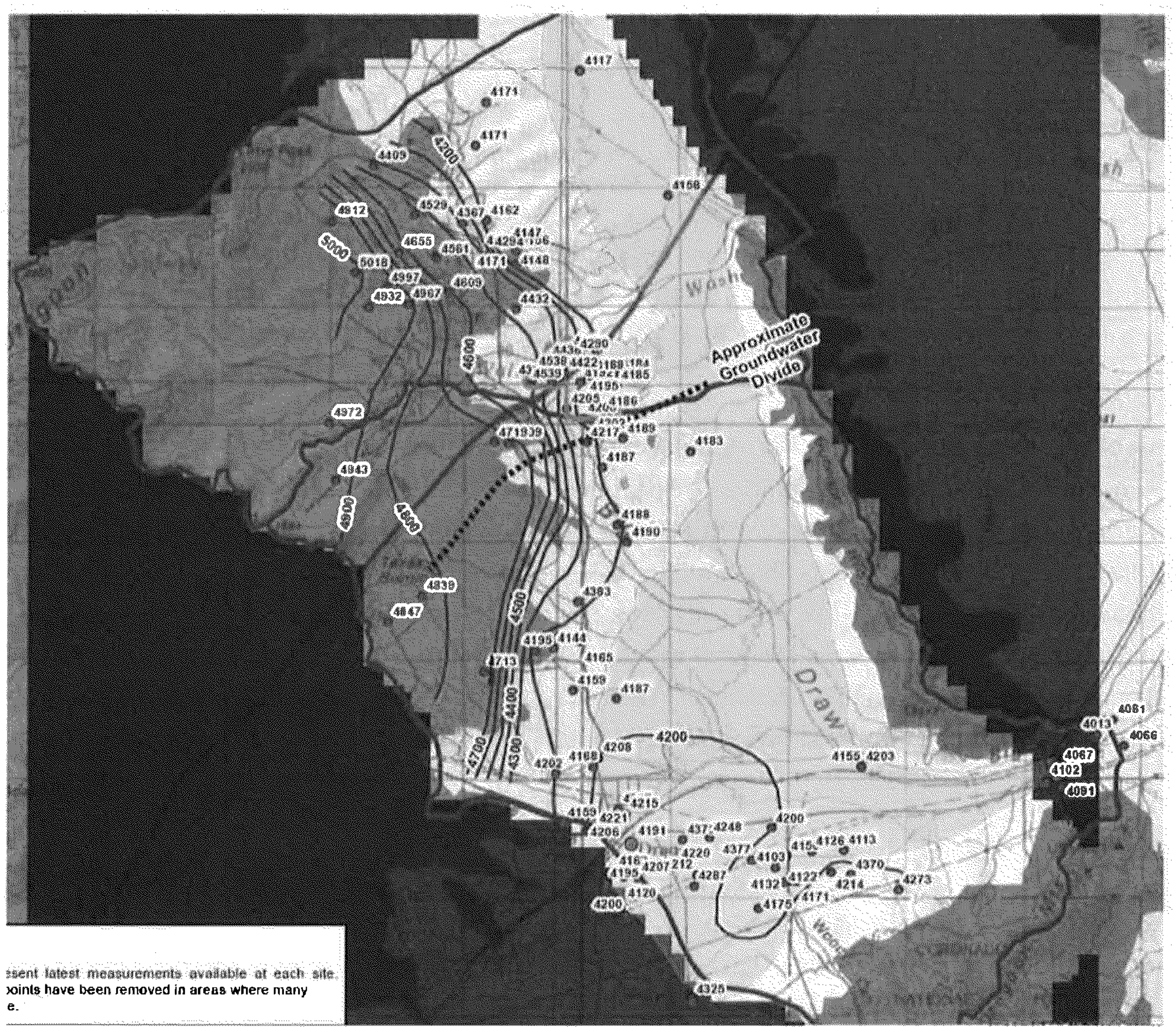


Figure 1: Figure 11 from Appendix I showing the regional potentiometric surface. The red boundary line is the bounds of the regional groundwater model.

CCA (2016) does not present a natural water balance for the aquifer. A water balance would be an estimate of recharge and discharge from the aquifer. The Application describes recharge properly in that it occurs from precipitation at higher elevations or from runoff through washes at low elevations, estimating that about 3% of the average 12.5 in/y precipitation becomes recharge across the basin.

- The hydrogeology discussion should present a water balance for the regional aquifer system, with an estimate of recharge and an estimate of groundwater flow leaving the basin through the two gaps on the east.

ADEQ response to Comment #6.1
ADEQ agrees that the groundwater model report did not provide a water balance. The permit has been modified to include groundwater flow model evaluations on a periodic basis as detailed in ADEQ Response to Comment #5.1. The report(s) will include a water balance.

Although the groundwater model report did not include a water balance, the calibration analysis conducted by Excelsior demonstrates that the model is calibrated. In addition, the sensitivity analysis conducted by Excelsior provided information on which of the hydrogeologic parameters the groundwater model is sensitive to. ADEQ believes the predictive capabilities of the model are adequate to evaluate the effectiveness of the proposed BADCT. Once long term injection/recovery and hydraulic control begins, the additional data will be used to re-evaluate and calibrate the model.

Geologic formations beneath the basin fill are in order of increasing depth are Me (Escabrosa Limestone), Dm (Martin Formation), Cau (Upper Abrigo), Cam (Middle Abrigo), Cal (Lower Abrigo), and Cb (Bolsa Quartzite) with pCu (PreCambrian Undivided) underlying these formations. These formations dip about 20 to 40 degrees to the east, and there are several near-vertical faults that offset the formations. Mineralization occurs in most of these with the base of the well field expected to be in the Cal formation (CCA 2016, Figures 3-5, -6, and -7). The bedrock surface is highly variable, which makes the basin fill thickness vary substantially. Bedrock elevation contours show significant variability over short distances, including drops of as much as 300 feet (CCA 2016, Figure 5-13).

Local Hydrogeology

There are 202 known wells within ½ mile of the project, although these are mostly mine exploration drill holes including those of Excelsior (Clear Creek Associates 2016, p 5-1). Most are owned by mining companies. Excelsior constructed 32 total wells through basin fill into the bedrock (Figure 2). The deepest wells, greater than 1400 feet, are in the south-central and southwest portions of the project area (Figure 2). There were additional coreholes drilled, to as deep as 2500 feet (CCA 2016, p 5-4).

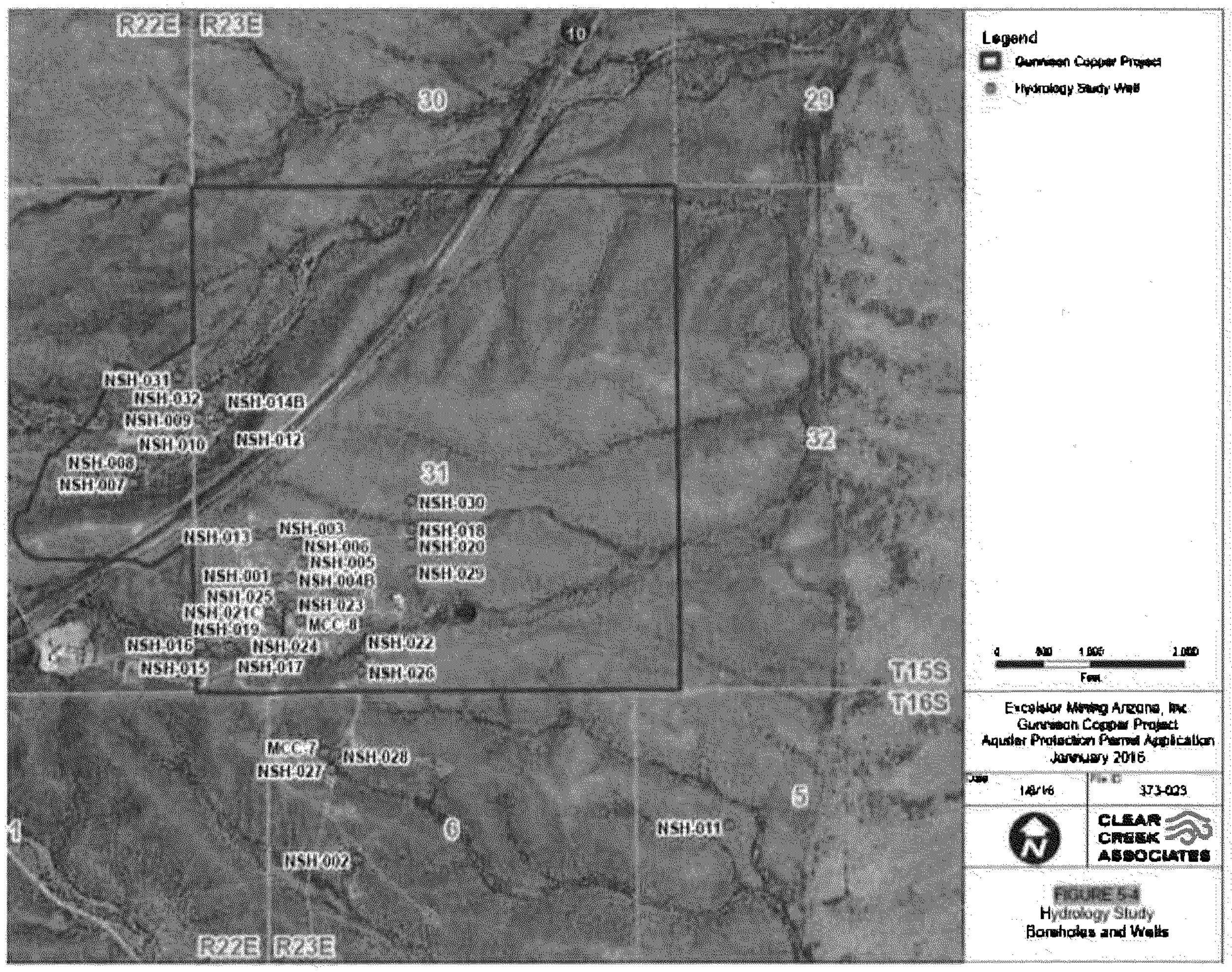


Figure 2: Figure 5-4 from CCA (2016) showing the boreholes and wells installed by Excelsior on and near the project site.

Aquifer Properties and Pump Tests

Excelsior (Appendix G) estimated most material properties using pump tests and geophysical techniques to estimate fracturing the various wells. Pump tests were completed with four two-hour steps followed by five days of steady state pumping and with three days of recovery monitoring. Drawdown in observation wells was monitored so there is an indication that properties in one direction is different from properties considered in a different direction, which may be the effect of fractures.

Appendix G Table 1 summarizes estimate transmissivity (T), maximum pumping rate (Qmax), and drawdown (Hmax) for each pump test. Transmissivity is the product of conductivity (K) and aquifer thickness. Conductivity K is the ease with which groundwater flows through a formation. The pump tests show a very large variability in T, more than three orders of magnitude, with values from 2 to 4000 ft^2/d (K varies from 0.01 to 9.8 ft/d based on thickness equal to pumping screen thickness, Appendix G, Table 3) and maximum pumping rates from 2 to 170 gpm. Lower pumping rates generally coincided with a low T. The author indicates that the variability "is to be expected as some wells were completed in highly fractured rocks while others were in unfractured or solid rock" (Appendix G, p 6). Because the formations dip, it is likely that most wells intersected some fracture zones so that T probably is related to the fracture density rather than simply the presence of fractures. The large range in K around the site indicates the site is highly heterogeneous. It is very likely that some layers intersected by the wells are the primary producing layers and that others produce very little, as demonstrated by the variability in pumping rates among the wells. The weighted averaging inherent in the estimated material properties does not account for this variability.

Appendix G improperly claims there is no horizontal anisotropy, which for K the horizontal anisotropy is the ratio of K in one direction to K in a different direction, usually perpendicular to the first. Observation well drawdown often varied depending on whether the observation well is screened in the same fracture zone as the pumping well (Appendix G, p 7). A plot of K and the azimuth between the pumping and observation wells shows a significant dependence on direction (Figure 3). The description of drawdown at well NSH-08 due to pumping at NSH-07 found that the significant drawdown at the pumping well compared to the observation well indicated flow to the pumping well likely came from a direction different than a direct pathway between the wells (Appendix G, p 8).

The pump test for well NSH-005, which is completed in bedrock, caused a larger drawdown in basin fill well NSH-006 than did the pump test directly in well NSH-006 (1.8 ft v 0.4 ft). Both wells are completed near the Forty Mile Fault structure (Appendix G, p 15). Well NSH-006 has about 30 feet of saturated fill so it is in the primary unconfined aquifer at the site. This substantial response indicates the fault connects the bedrock with the basin fill so that stresses in the bedrock that affect the fault will also affect the water in the basin fill. This observed connection suggests that injected water (lixiviant) near this location could be forced upward into the unconfined aquifer. Pump testing at NSH-006 caused only 0.4 feet of drawdown but the pumping rate was very low; small drawdowns were observed at two bedrock wells (Figure 37) confirming the connection. It would have been useful to pump this well at a higher rate to better test the connections to the bedrock aquifers.

Appendix G presents a directional plot of conductivity with azimuth, which they claim shows they can average the K values without considering direction (Figure 3). Rather than showing "that the hydraulic conductivities are relatively evenly distributed with little prevalent direction" (Appendix G, p 31), Figure 3 shows a substantial correlation with direction. This is especially true for a direction from midway between north and northeast and between south and southwest, where the K exceed 4.0 ft/d, and for a roughly perpendicular direction along which K is just over 3.0 ft/d. Additionally, between those transverse K trends, there is another line of about 3.2 ft/d trending from between north and northwest to between south and southeast. K in other directions is less than half as much. The trends show a perpendicular fracture pattern, but does not demonstrate that "the fracture patterns intersect sufficiently at the well spacing of 100 feet to smooth out, for the purpose of hydraulics, discrete fracture spacing which is on the order of one foot" (Appendix G, p 31). There is nothing in the Appendix, or anywhere in the Application, that indicates the spacing of the intersection of fracture patterns or of one-foot discrete fracture spacing.

Figure 123. Compilation of K-values from the Gunnison ore body by azimuth and magnitude

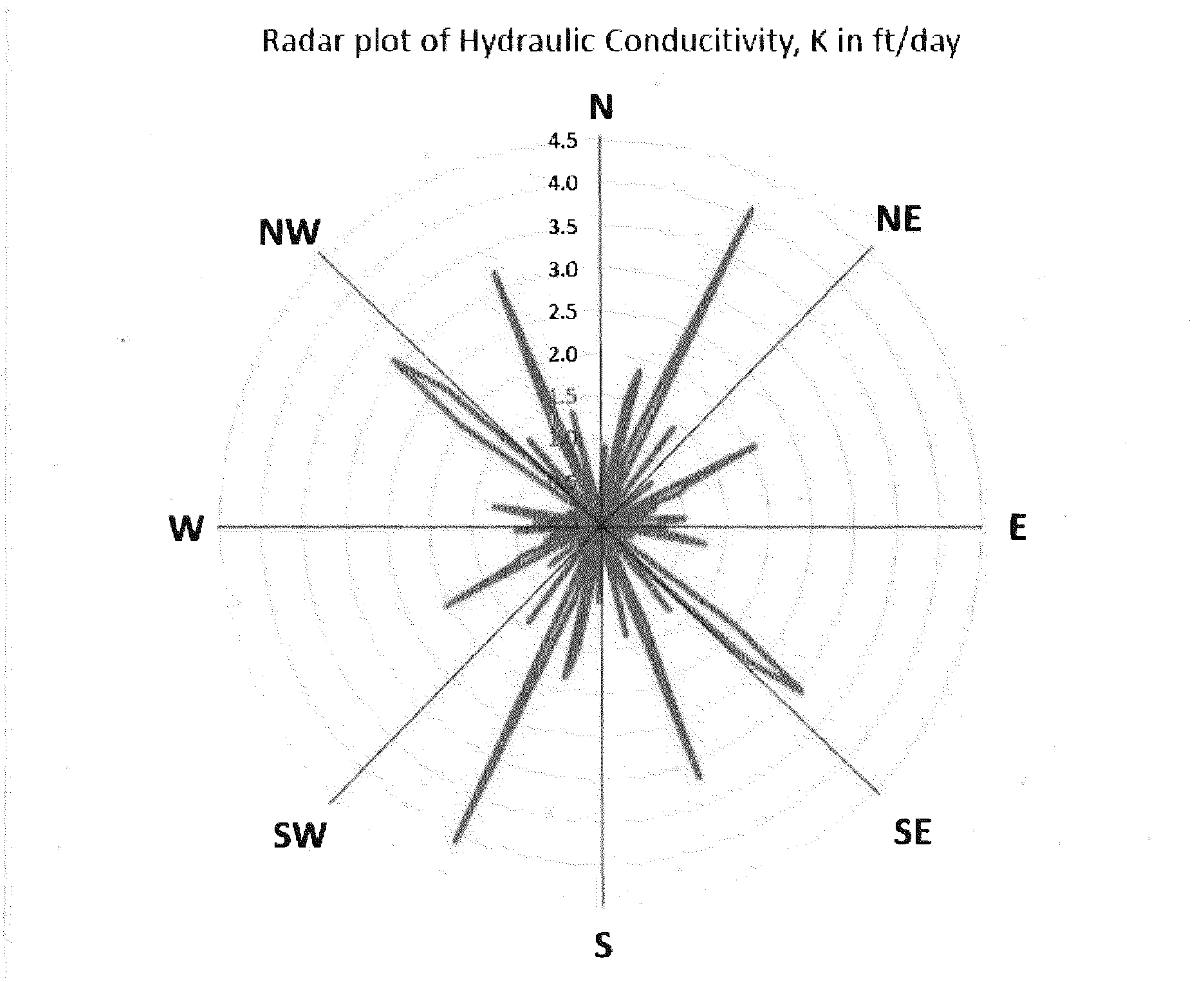


Figure 3: Figure 123 from CCA (2016) Appendix G showing the relation of hydraulic conductivity with azimuth between pumping and observation wells.

The property data identified in Appendix G was used "to populate and calibrate the hydrogeological flow model" (Appendix G, p 32), but they ignore heterogeneity and directional tendencies.

The application claims that even "the low-yield wells demonstrated long-distance hydraulic connectivity with observation wells" (CCA 2016, p 5-12), based on responses even when the wells were not screened in the same fracture zone. In a confined aquifer, a stress in one location will propagate as a pressure response in all directions; Excelsior properly references this response as indicating the aquifer is confined. However, Excelsior may be implying that this means that groundwater (and contaminants, or lixiviant) will flow from one point to the other. As noted in the pump test analysis, due to the directional tendency of the fractures, much of the flow may be parallel. Pressure responses occur in all directions in a confined aquifer, and may not represent proof of flow between the two points. This interpretation is important because of the need for the injection/collection system to capture flow from all points of the system.

However, Appendix I notes that in bedrock the model treated K as equal in all directions except for the basin fill. By not considering anisotropy the Application (most importantly in the modeling) ignores preferential flow either on the horizontal plane or vertically. Fractures trend from northwest to southeast which suggests the K along that direction should be considered higher than in other directions. The formations dip to the east which also suggests that K is higher parallel to the dip than in other directions. The Application ignores these issues even though geologic figures presented within the application provides the relevant evidence regarding the dip. For example, drawdown from pump tests in an observation well more than 1000 feet from pumping wells indicates "good connectivity" (Id.) in a prevailing direction between the pumping and observation wells.

- Excelsior should consider horizontal anisotropy in its modeling and project design. The effects of not considering this are better considered below in the discussion of modeling.

ADEQ response to Comment #6.2

The groundwater flow model does consider horizontal anisotropy in its design. The major faults systems are presented with higher hydraulic conductivity values essentially creating anisotropy within the model. This method also accounts for any preferential flow paths (major fault systems) that may be present. In addition, Excelsior provided in the April 2017 "Gunnison Copper Project, Cochise County, Arizona, Aquifer Protection Permit Application Inventory No. 511633 Response to Comments" several figures that show the horizontal area of influence for aquifer testing conducted at the site. These figures indicate the primary preferential flow paths are the major fault sytems. These figures include Figure 2-1 "Aquifer Testing Area of Influence, NSH-013", Figure 2-2 "Aquifer Testing Area of Influence, NSH-021C", Figure 2-3 "Aquifer Testing Area of Influence, NSH-024", and Figure 2-4 "Aquifer Testing Total Area of Influence: NSH-013,NSH-021C, NSH-024".

Additional figures provided the locations of IMWs to be used to monitor Mine Block 1 along with an overlay of the aquifer testing total area of influence shown in Figure 2-5 (Figure 2-5 "Intermediate Monitoring Well Locations: Year 1"), locations of Mine Blocks 1 through 5 with the same aquifer test overlay shown in Figure 2-6 (Figure 2-6

"Intermediate Monitoring Well Locations: Year 5). This same evaluation and figures were presented for Year 10 and Year 13 (Figure 2-7 "Intermediate Monitoring Well Locations: Year 10" and Figure 2-8 "Intermediate Monitoring Well Locations: Year 13"). These figures are included below in ADEQ Response Figures.

Excelsior also did not interpret the pump tests according vertical connectivity or use available core holes to determine connectivity of wells within the proposed well field and formation beneath well field. As noted, coreholes had been completed to as much as 2400 feet bgs. During the pump test, Excelsior missed an opportunity by not recording the response within those deep wells. The application presents no information or evidence regarding the potential for pumping the injection/collection wells on groundwater beneath the site. This could be important because the formations and groundwater at depth are sulfide.

- Excelsior should complete at least one longer term pump test using the higher producing wells and monitoring their wells both within the well field, outside the well field, and beneath the well field. This would provide improved evidence regarding connectivity throughout the aquifers near the project site.

ADEQ response to Comment #6.3
ADEQ considers aquifer testing conducted by Excelsior to be adequate. Most of the alluvium at the mine site is unsaturated. Small portions that are saturated are only thinly saturated, isolated and will not be affected by injection/recovery activities. Excelsior conducted two aquifer tests in the underlying sulfide bedrock aquifer which indicated much lower hydraulic conductivities (both 0.001 feet per day (ft/d)). Based upon this data, the APP did not include groundwater monitoring within the sulfide bedrock aquifer.

Most of the storage coefficients from tests near the proposed well field indicate confined conditions, although there are exceptions usually on one or more of the observation wells for a given test. Storage coefficients indicate how much water would be released from storage due to a change in pressure within the aquifer. The values vary as much as six orders of magnitude which indicates great variability and that no average value should be applied over the entire model domain. Storativity probably varies among bedrock type and among the fracture density, thus no estimate will be accurate for the entire domain. This is a critical problem for the modeling because storativity controls the amount of water that would be released for a given change in potentiometric surface.

Estimated porosity values from pump tests are minimum because drawdown at the observation wells had not come to equilibrium (CCA 2016, p 5-14). Excelsior also used gamma-gamma logs to estimate porosity for each 0.1 feet down the wellbore, but presents only a weighted average for seven wells and determines only an overall estimated porosity of 0.0277 (Application Table 5-7). Values for the wells vary from .0133 to .0577, a substantial range which demonstrates significant variability across the site. It is also likely the vertical distribution of porosity along a given well would be much more variable as the well bore intersects fractures and intact bedrock. Presenting graphs of how porosity varies vertically along the wells would illustrate the vertical variability and the potential for preferential flow. The more variable a formation is in the vertical direction, the more potential there is for vertical flow paths and the less potential there is for a hydraulic barrier formed by pumping wells to prevent water from escaping the well field.

ADEQ response to Comment #6.4
The groundwater model did not contain single values for storage coefficients for each formation. Table 10 of Appendix I indicates the estimated storage coefficients and porosities for each type of geologic formation within the model domain based upon the fracture intensities observed from cores. As noted in ADEQ response to Comment #6.2 and #6.3, there is no evidence that the vertical flow is greater than horizontal flow or that the hydraulic barrier created by the HCW would not be effective. In addition, the IMW network is designed to increase monitoring between the active mining block(s) and the HCWs, with contingency requirements for additional HCWs, if needed.

Water Chemistry

The groundwater is generally a calcium-sodium-magnesium-bicarbonate type with TDS varying from 210 to 420 mg/l, with some high fluoride concentrations. Samples from the sulfide zone are sodium-carbonate-bicarbonate or sodium-bicarbonate-chloride-sulfate with higher TDS (p 5-6). Metals are generally low but there were some hits of volatile organics. Excelsior reported petroleum products in the groundwater on the project site. Coreholes CS-10 and CS-14 had free petroleum product in the groundwater, which means there is LNAPL (light, non-aqueous phase liquid) floating on the surface of the water (Figure 4). After pumping it from the corehole, it reappeared and was 0.25 feet thick in about ten days (CCA 2017a, p 5-8). That indicates there is a significant source of LNAPL near the site. The clustering of wells with different hydrocarbons, as seen by the distribution of hydrocarbons in Figure 4, may reflect different transport and attenuation rates for the different products within the fracture zone affected by the source. The intermixed wells without any hits may be screened in different fracture zones.

ADEQ response to Comment #6.5
ADEQ does not consider petroleum hydrocarbons a significant issue to liner performance, SX-EW performance or additional impacts to the aquifer. Based upon Excelsior's response to ADEQ comments in June 17, 2016, the hydrocarbons appear to be related to old drilling methodologies which used petroleum fluids during drilling and residual contamination from the former Leaking Underground Storgage Tank (LUST) release from "The Thing" near the southwest corner of the site. Mining will extract any remnant hydrocarbons which will then be processed with the other extracted fluids.

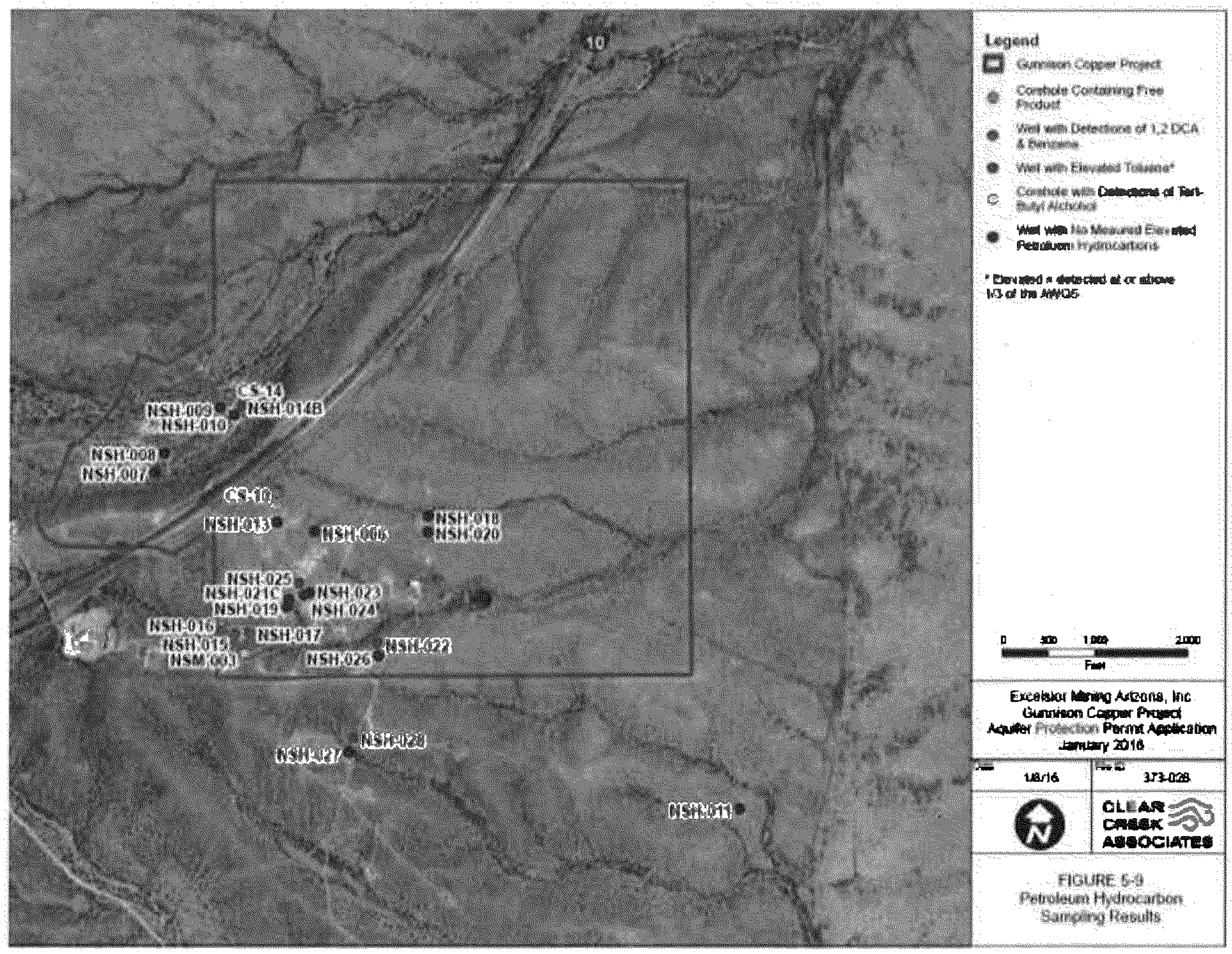


Figure 4: Figure 5-9 from Clear Creek Associates (2017a) showing the wells and coreholes with petroleum hydrocarbon hits.

Excelsior explains the potential sources are The Thing gas station and the Johnson Camp Mine, although the mine may not have stored petroleum products (CCA 2016, p 5-9). The Thing site had underground storage tanks removed in 1996 because there had been contamination detected in the soil. ADEQ closed the case files investigating the contamination between the substantial depth to groundwater (hundreds of feet) and the presence of bedrock just two feet below the tanks. Most of the detections (Figure 4) are potentially downgradient of the Thing site (Figure 5). If indeed The Thing is the source, there has been substantial transport and lack of attenuation, which could be a significant source of contamination to the project.

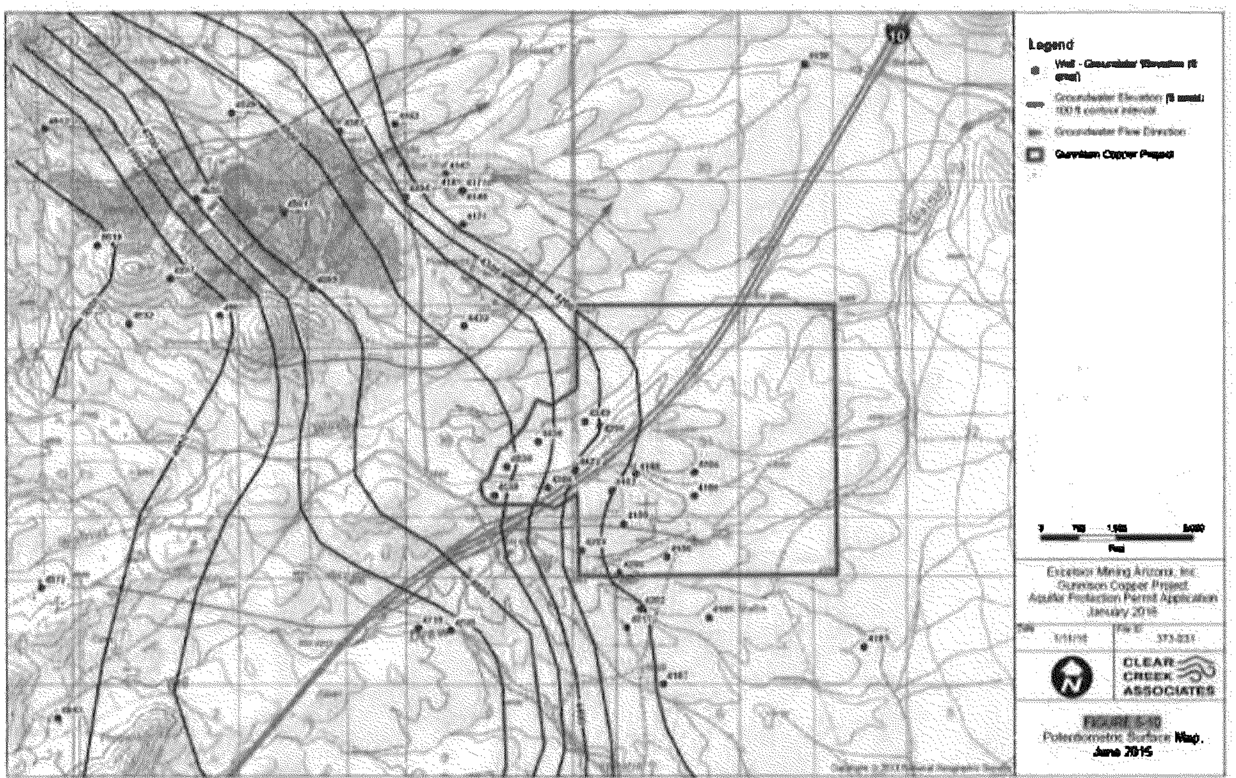


Figure 5: Figure 5-10 from Clear Creek Associates (2016) showing the potentiometric surface at the site and to the west and northwest.

As noted, the mine apparently did not use gasoline, so Excelsior seems convinced that it could not be a source (CCA 2016, p 5-9). They also point to the gradients of the potentiometric surface which suggest that groundwater flow from the mine would be to the northeast and would miss the project site by a mile or more. The potentiometric surface (Figure 5) appears to drop steeply northeast of the mine and appears to form a ridge on the west side of the project site.

- Due to the importance of understanding the source of petroleum products, Excelsior should reconsider the potentiometric surface map to consider whether the water levels used for mapping all represent the same aquifer level. In a fractured rock aquifer, it is not often appropriate to assume there are no vertical gradients. The map with water level with respect to the top of the bedrock (Figure 5-12, CCA 2016a) shows significant variability in small areas, suggesting that it is possible the water levels represent different bedrock levels. It is possible that groundwater flows southeast from the mine at certain levels. For this reason, the mine cannot be ruled out as a source.

__ADEQ response to Comment #6.6__
Please see response to Comment #6.5.

- Hydrocarbons in the groundwater could affect the chemistry of the project. Excelsior must complete a larger survey of the LNAPL contamination and assess whether and how it could affect ISL operations.

__ADEQ response to Comment #6.7__
Please see response to Comment #6.5.

Copper Mining Project

The project is an in-situ leach and recovery project for copper in the bedrock formations underlying the basin fill at the site. The project involves injecting an acid solution into the groundwater of the bedrock aquifers so that it can leach Cu which would then be recovered in capture or collection wells. The project involves the construction of various ponds and a solvent-extraction electrowinning plant (SX-EW plant). The SX-EW plant would be at the Johnson Camp mine during phase 1 and then just east of the mine in phases 2 and 3 (the second ten years of the 20-year project life) (Fact Sheet, Clear Creek Associates 2016, p 1-4). The site plan (Figure 6) only shows the SX-EW plant at the mine site.

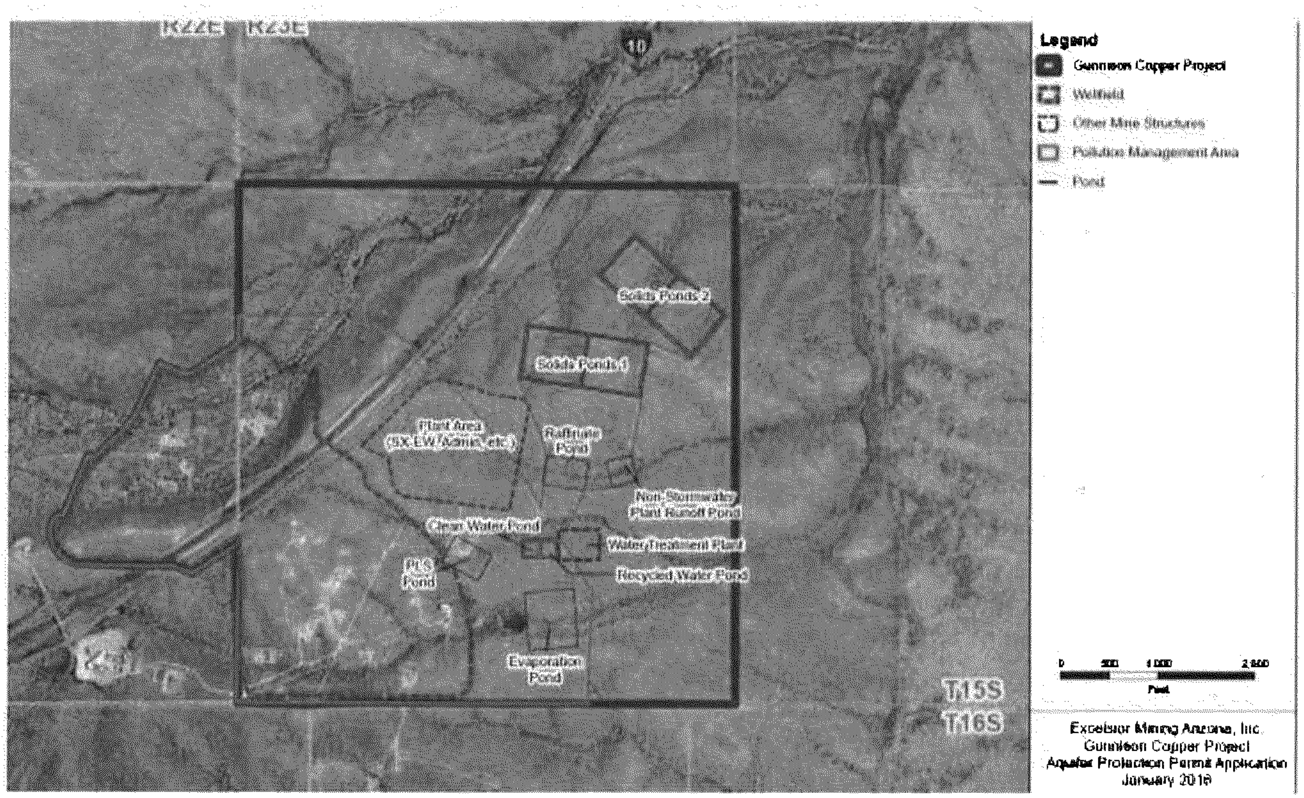


Figure 6: Facility site plan, from Figure 1-2 (Clear Creek Associates 2016)

The well layout would have four collection wells surrounding each injection wells. However, the map of the well field (App I, Figure 44, shown below in the review of groundwater modeling as Figure 17) shows a 5-spot well pattern that shows that each collection well would be part of the four collection wells for at least four injection wells. The development blocks (App I, Figure 45) indicate that sections of the well field would be developed such that 5-spot patterns would overlap with adjacent 5-spot patterns which would cause the 4:1 collection to injection well ratio to not hold throughout the project life.

ADEQ response to Comment #6.8

As discussed throughout the application and response to ADEQ comments, the 5-spot pattern is the base design for in-situ mining. In Stage 1, 200 injection/recovery wells are planned to be constructed. Each 5-spot is planned to be part of other 5-spots. For example, each of the recovery wells for one 5-spot will be recovery wells for the adjacent 5-spots. Therefore, the recovery well to injection well ratio will vary, as planned, over the life of the mining operation. The ratio of the amount of fluid injected to the amount of fluid recovered in each mining block will remain approximately 1:1.

The injection rate would vary with time throughout the project life (CCA 2016, p 7-5). Total rates range from 5300 to 25,600 gpm with the lower rate for the first ten years. They also propose to limit pressure to 0.75 psi/ft of screen length. The actual injection rate would depend on the pressure, but there is no discussion of that. Pressure is limited to avoid fracturing the rock.

The injection/collection process would collect more water than is injected, which should cause a general drawdown within the well field. A line of collection wells would surround the well field and be designed to withdraw water and create a trough in the potentiometric surface intended to prevent water from within the wellfield from escaping from the wellfield. Predicted drawdown from hydraulic control wells would extend to the east of the well field by 1200 to 1500 feet from the control wells at maximum pumping based on modeling (Application, p 5-15). Also, modeling suggests drawdown would never exceed 50 feet (Id.). There is no guarantee that these wells would intercept flow in each preferential flow path. As described below in the groundwater modeling section, the model uses model cells with averaged material properties, so estimated drawdown is an average for the cells that does not account for preferential flow paths. The model does not consider the potential for fractures to transmit flow and contaminants from the well field. The modeling includes MODPATH simulations which are described below in the Groundwater Modeling section.

ADEQ response to Comment #6.9

Please see response to Comment #6.2 on the comment about the influence observed by aquifer testing conducted by Excelsior and what their interpretation indicated about preferential flow paths.

> *In response to the comment about injection pressure, the rate of 0.75 psi/ft takes into account depth of the well to avoid fracturing the rock. The overall injection rate is determined by the processing facilities capacities, not by injection pressure. Each well operates below the fracture gradient pressure and overall flow is adjusted by the number of wells and flow restriction valves.*

The system works by injecting acid-rich barren solution into the ore-bearing aquifer. The low pH leachate would dissolve copper, and other metals from the ore. The processing of the pregnant solution would remove copper, after which the solution would be recycled to be used for leaching again. Acid would be added to lower the pH once again before being reinjected into the ore body. The processing of copper would allow most other metals to remain in solution, so that the water being circulated through the system would have concentrations of metals and some anions that are multiple times their water quality standards. Concentrations of cadmium, lead, selenium, nickel, thallium, zinc, and fluoride, among others, would be orders of magnitude higher than background levels and most water quality standards (CCA 2016, Table 6-1, Appendix J-3). The incredibly poor water quality of the leach solution exemplifies why preventing any of it escaping the system is critical.

Excelsior argues this site is favorable for "maintaining control of the leach solution" (Application, p 7-2) because there are no drinking water aquifers, or underground sources of drinking water (USDW) above or below the zone of injection, and there is limestone within and downgradient of the wellfield which would provide a large attenuation capacity. The well field would be sandwiched between mostly unsaturated basin fill and a mostly low permeability sulfide zone below. The application presents evidence that the potentiometric surface is above the base of the alluvium in some areas which would confirm the target zone is a confined aquifer, which means pumping it would have little effect on water levels in any saturated layers above the target zone. The underlying sulfide zone has low conductivity, as confirmed with two pump tests which at 1 and 4 gpm caused substantial drawdown.

Excelsior's claim regarding downgradient attenuating formations is too broad with respect to the downgradient Escabrosa and Horquilla limestone because they fail to consider how much of the amount of neutralizing carbonate rock would actually contact any acid escaping the well field. If acid escapes and contacts the limestone much of it could be neutralized, but only if the acid solution actually contacts the limestone. If the acid solution preferentially flows through fractures in the limestone, it may use much of the carbonate within the fractures so that the remaining acid would flow through without actually contacting the neutralizing limestone. Analyses that simply show the limestone has sufficient neutralizing capacity, such as Appendix J-1, but do not assess the flowpaths through the limestone cannot prove the downgradient formations are an adequate buffer. The limestone should not be relied on to neutralize acid that reaches it unless there is an accounting for the effective neutralizing capacity of in situ limestone.

- Excelsior should provide a realistic assessment of attenuation capacity considering the amount of limestone that escaping acid solution would contact.

ADEQ response to Comment #6.10
Please see response to Comment #6.2 as it relates to preferential flow paths. In evaluating the neutralizing potential of downgradient limestone, the geochemical model took into account the estimated secondary porosity of 3% for the downgradient limestone.

The injection/collection well fields would be rinsed after the copper has been removed to flush the contaminants from the aquifer and the groundwater. The plan includes rinsing with three pore volumes of freshwater (Stage 1), follow by rest (Stage 2), followed by rinsing with two more pore volumes (Stage 3) (CCA 2016, p 7-11). The rest period allows the latent solution to reside in the pores where ongoing neutralization would occur. They estimate this would require a year. The injection/collection wells no longer being used would be abandoned and closed. The standards for determining when rinsing is done are water quality standards in random samples (Application, p 7-12).

- The pore volumes have been estimated assuming 3% porosity. This should be established as minimum, because average porosity at the site is slightly less than 3%, but Excelsior should estimate porosity for the ore body for each well as it is constructed and logged. As noted above, porosity in some of the wells exceeded 5%. If porosity is higher than 3%, the amount of rinsing should be increased accordingly.

ADEQ response to Comment #6.11
The permit requires continued rinsing until constituents with aquifer quality limits (AQLs) return to permit requirements. Please note rinsing is proposed to occur in three stages for each mine block.

The draft permit does not establish the standards, referred to as rinse verification standards. Table 4.1-7 in the draft permit should specify standards but only has "monitor" or "reserved".

- The APP should specify the numerical standards to which rinsing will be continued upon closure.

ADEQ response to Comment #6.12
APP typically allows for ambient conditions to be evaluated after Individual APP issuance. The APP contains language in Sections 2.5.3.1.2, 2.5.3.2.1, and 2.5.3.3.1 to conduct ambient groundwater monitoring along with compliance schedule items in Section 3.0 that specify when the permit is to be amended to set alert levels (ALs) and AQLs.

Monitoring the Project

The Gunnison Copper Project would utilize three types of wells to maintain and monitor hydraulic control: Intermediate Monitoring Wells (IMW), Observation Wells (OW), and Hydraulic control wells (HCW). The project would also deploy Point of Compliance (POC) wells outside the area of hydraulic control to detect contamination migrating away from the site. While the IMW, OW, and HCW wells are critical in controlling and monitoring mining operations, the POC wells provide the best indication of contaminants migrating away from the well fields.

Excelsior proposed five POC wells located outside the area of review (AOR) (CCA 2016, p 5-18) (Figure 7). The AOR is roughly the hydraulic barrier created by the hydraulic control wells. The five POC wells are grossly insufficient for two reasons. First, the wells would be "screened in bedrock, with the top and bottom of the screen set at approximately the same elevations over which the injection wells are open". This would ultimately be a screen over hundreds of feet, which is grossly insufficient to detect contaminants moving off of the site. Contaminants escaping the site would follow preferential flow pathways, so even if the screened intervals intercept the flow paths, the contaminants would be highly diluted by mixing with groundwater higher and lower than in the aquifer.

Second, five wells spaced along the pollution management area perimeter (Figure 7) is grossly insufficient spacing. Large contaminant plumes could flow between the wells undetected. Also, their placement assumes the potentiometric surface gradient is adequately known to be sure there could be no movement to the south, north, or even west. This is an unsupported assumption because, as discussed elsewhere, heterogeneities and preferential flow paths could cause flow paths that are not perpendicular to the general contours.

There would also be five POC wells downgradient of the impoundments (Figure 7), intended to detect leaks from those impoundments. POC wells 9 and 10 would monitor along the downgradient side of solids ponds 1 and 2. Having just one well for each of these ponds is insufficient because they would only detect contaminants that leak into a flowpath directly upgradient of the well. The size of these ponds should make obvious there are many areas that could contribute contaminants that would not be upgradient of the POC well. These POC wells would detect contaminants that reach the water table through the unsaturated zone, so the source would be at the water table. They would disperse vertically, but not that deeply. The wells should screen the water table and extend below the water table the minimum possible to be sure that water table does not fall below the well. The 60-foot proposed screen thickness is far too large to adequately detect contaminants at the water table because it would allow for cleaner, deeper water to dilute the contaminants.

- The number and spacing of POC wells should be determined by modeling of contaminants being released either within the well field or the ponds accounting for horizontal dispersion. Well-spacing should be less that the width of simulated plumes at the line of POC wells.

ADEQ response to Comment #6.13
ADEQ does not agree that monitoring groundwater in the POC wells is the best and most expedient way to determine whether there has been an excursion from the mine blocks. Monitoring from the IMWs and OWs is a much more expedient way to determine whether there has been an excursion and allows for changes of recovery rates and allows the excursion to be recovered. At this time there is no reason to include additional POC wells. For conceptual POC locations related to lined impoundments, wells would only be installed if there was an impoundment failure. The Response to ADEQ Comments dated April 2017, Figure 9-1 "Discharge Impact Area and PMA Boundary" provides a revised evaluation of the discharge impact area (DIA) and revised location of the POCs.

- The POC wells downgradient from the well field should monitor different vertical preferential flow paths separately. That means that at each POC well location, the wells should monitor each potential flow zone. Either nested wells or multiple opening wells could be used. Multiple screened openings along the bore hole no more than 20 feet long would be preferable so that the depth of the contaminant couldbe determined.

ADEQ response to Comment #6.14
At this time, vertical profiling of groundwater at the POC well locations is not warranted or required due to the interconnectivity of the bedrock and the extensive monitoring within the PMA.

- The POC wells below the ponds should span the water table to adequatelymonitor contaminants that could reach the water table. The screen length should be the minimum possible to avoid the water table dropping below itsbottom.

ADEQ response to Comment #6.15
The POCs related to the double lined impoundments are conceptual. If a POC well related to a lined impoundment is ever required to be installed, the screens will be across the water table per the APP.

- POC wells should extend along the north and south boundaries, with some buffer as established on the east side, to assure that contaminants do not flow inunpredicted directions.

ADEQ response to Comment #6.16
ADEQ is requiring extensive monitoring near the mine blocks. If, based upon an evaluation of groundwater monitoring data, more POC wells are required, primarily in

the south, then ADEQ will require Excelsior to install and monitor additional POC wells. However, the addition of additional POC wells is not warranted at this time.

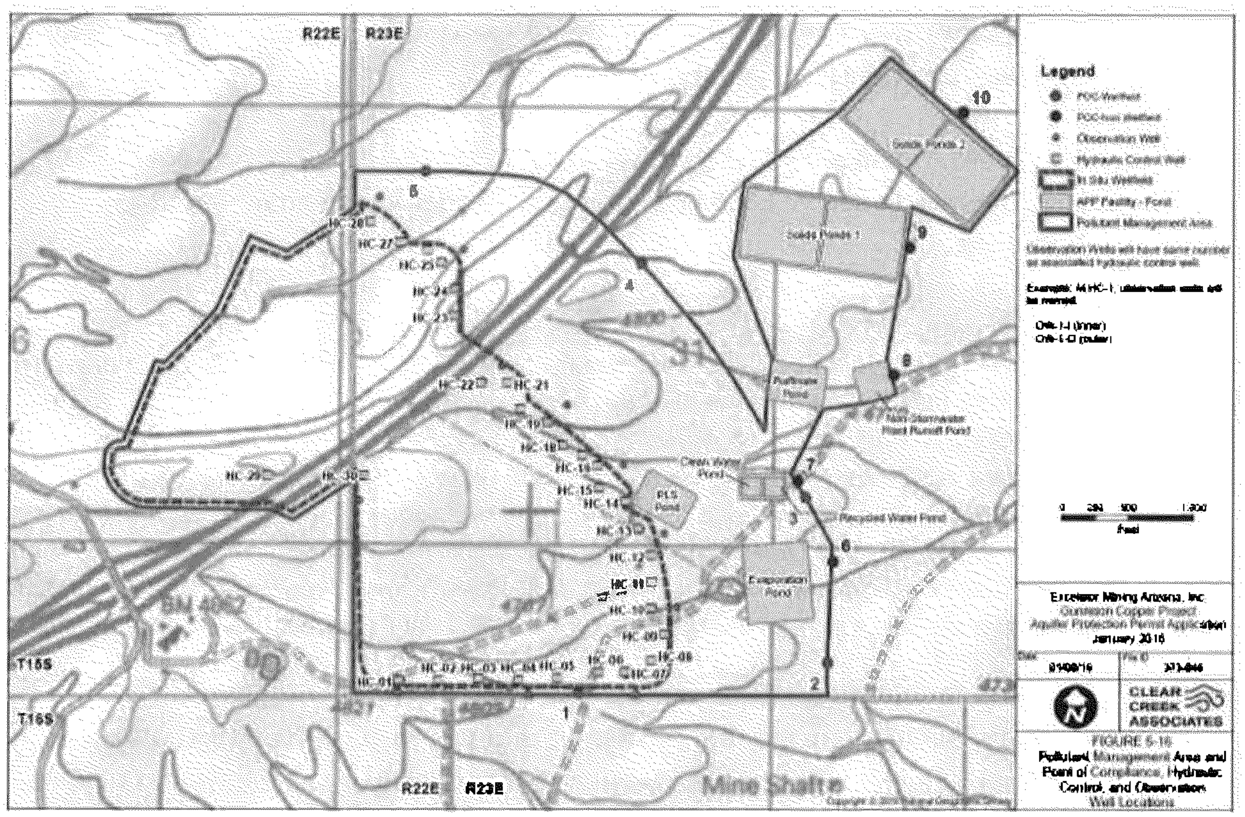


Figure 7: Figure 5-16 (CCA 2016) showing the point of compliance wells, observation wells, and hydraulic control wells.

The concentration limits specified for the POC wells are grossly insufficient, which is unfortunate because the POC wells are the last line of defense for determining that contaminants are escaping the well field. First, many of the parameters would only be monitored with alert limits set for fluoride, nitrate+nitrite, antimony, arsenic, barium, beryllium, cadmium, chromium, lead, mercury, nickel, selenium, thallium, adjusted gross alpha, radium 226+228, benzene, toluene, ethylbenzene, and total xylenes. The draft permit would only require monitoring for various other parameters; some monitor-only parameters, including total dissolved solids (TDS), specific conductivity (SC), and pH (Draft Permit, Table 4.1-5B), are the best indicators of a problem with the well field.

The draft permit establishes ambient groundwater monitoring for the POCs that should be completed prior to commencement of mining. It would require a minimum of 8 and maximum of 12 sampling events, with a minimum frequency of weekly and maximum of quarterly (Draft permit, section 2.5.3.1.2). because this could be completed in as little as 8 weeks, the sampling could reflect ambient conditions for only a portion of the year.

The method for setting the alert level based on observed ambient conditions, with AL=M+KS with M being mean, S being standard deviation, K being the one-sided normal tolerance interval with a 95% confidence limit is standard. The concentration values would account for dilution if the screens are too large, as described above.

- The alert limits and aquifer quality limits should be set and enforced for each POC, by screened interval, to set limits and commence mitigation based on preferential pathways.

ADEQ response to Comment #6.17
Please see ADEQ response to Comment #6.14, in relation to how the interconnectivity of the bedrock allows for the permitted method of setting ambient groundwater quality. In addition, in setting ALs and AQLs, if concentrations of constituents are not detected above their respective AWQSs, the AQL will be set to the AWQS, so statistical "dilution" will not take place. In relation to the list of constituents being monitored as not being extensive, ADEQ does not agree. The list is very extensive and protective for the downgradient aquifer. As to the statement that the APP only requires monitoring for ALs, the commenter is incorrect. The constituents listed by the commenter include both ALs and AQLs.

- The permit should require monitoring of pH in addition to SC at the IMWs, OWs, and HCWs; that could provide good early warning of a loss of hydraulic control through pathways.

ADEQ response to Comment #6.18
The deposit located within limestone host rock. For this reason, pH would not be as indicative of an excursion as would specific conductance (SC), which will indicate groundwater has been impacted by the in-situ operation.

- The concentration limits specified for POC wells should account for dilution. This would account for the fact that standards could be exceeded over a portion of the water column but not all of it. Failing to acknowledge that can lead to downgradient resources being affected if they depend only on a small thickness of the aquifer.

ADEQ response to Comment #6.19
The accepted groundwater monitoring and sampling methodology listed in Section 2.5.3 of the APP takes into account the concerns listed above.

The draft permit specifies various actions that will be taken if alert levels are exceeded, but they are in the longer term insufficient. The draft permit must indicate that if exceedances last for more than six months, the facility, or at least the specific section of the well field responsible for the exceedance, must cease operations and commence rinsing. This is because the exceedance is an indicator that the hydraulic control has been lost. Exceedances lasting more than six months indicate that other steps taken have not worked. The only way to protect downgradient aquifers would be to cease operations.

<u>ADEQ response to Comment #6.20</u>

ADEQ does not agree that the contingency language in the permit is insufficient. Per Section 2.6.2.4.1.1 of the APP, Excelsior is required to conduct the following actions if the SC is exceeded at the HCW and/or OWs:

a. Continued monitoring
b. Adjust operations to reverse the trend (pull back solutions)
c. Adjust pumping in the appropriate HCWs
d. Install and activate additional interceptor HCWs (if not already installed)

In addition, Sections 2.6.2.4.3.1 and 2.6.2.4.3.2 require cessation of operations in the event of loss of inward hydraulic gradient and net extraction.

Excelsior proposed the POC wells be monitored for four quarters after rinsing is complete (CCA 2016, p 7-13). These wells are downgradient of the entire well site, so this presumably means the monitoring would continue for just one year beyond the end of rinsing. The length of the monitoring period is insufficient because it is not long enough for contaminants residingwithin the well field, but not neutralized, to flow from the well field through the POC wells. Particle tracking in the groundwater modeling (Appendix I) shows that particles have not yet reached the edge of the mine within years, so there would be substantial time for residual particles to reach the POC wells.

- Monitoring beyond the end of rinsing should continue as long as the estimated travel time for particles from the most distant part of the well field to reach the POC line, plus at least 50% for a safety factor.

<u>ADEQ response to Comment #6.21</u>

Section 2.9.1.2 of the APP indicates that when all Closure Verification Wells (CVW) have met rinse verification standards for five consecutive years, monitoring may stop and all wells (Rinse Verification Wells (RVWs), CVWs, HCWs, Observation Wells and POC Wells) may be plugged and abandoned. This condition is protective, as it requires no exceedances of AWQSs, or ambient conditions if AWQSs are exceeded during post-closure monitoring, within the wellfield and the Observation Wells. This requirement will ensure that there will not be an exceedance in the POC Wells after the end of the post-closure groundwater monitoring period.

There would be OWs included on the site, as shown in Figure 7. However, the draft permit and the application refer to observation well pairs (Draft Permit, Table 2.5-2), but none of the figures show enough detail to show what a "pair" means. They are intended to show that the hydraulic control wells are maintaining an inward gradient. There are insufficient OWs shown in Draft Permit Table 2.5-2 to show the gradient at each hydraulic control well. The observation wells are insufficient for proving the maintenance of an inward hydraulic gradient, as described in the Draft Permit, section 2.6.2.4.3.

POC wells are designed for compliance monitoring and would be sampled quarterly with provision for more frequent sampling once exceedances occur. The IMWs, HCWs, and OWs are used for internal flow management and are monitored for SC (and preferably pH, as suggested above) on a daily basis. The HCWs and OWs would also be monitored for groundwater level.

- POC monitoring should be conducted monthly during the first year of commercial production, bi-monthly in the second year, quarterly from year three through five, and biannually thereafter. POC wells should be drilled at least one year prior to commercial operation so that baseline data gathering can begin at all of them.

ADEQ response to Comment #6.22
Due to the long travel times of solutions to the POC wells, greater than 23 years, there is no valid reason to conduct an increased frequency of groundwater sampling as commented above. Three POC Wells are installed prior to initiation of Stage 1. Two additional POC Wells are installed in the northeast prior to the initiation of Stage 2.

- Instead of daily sampling, SC, pH, and water levels should be monitored using automated sensors to save costs of visiting the wells daily and to provide real-time control over operations onsite.

ADEQ response to Comment #6.23
The APP allows Excelsior to collect SC samples either by groundwater sampling or a data logger.

There are facilities on the mine site, other than the injection/collection wells, that can lead to groundwater contamination, including two solids ponds, a raffinate pond, PLS pond, evaporation pond, and recycled water pond (Figures 6 and 7). The draft permit does not indicate whether these ponds would have liners, although Table 1-1 of the application indicate they would be lined. The draft permit only discusses liner failures.

- The draft permit should be amended to specify which ponds require a liner and what kind of liner (thickness) with leak detection required.

ADEQ response to Comment #6.24
Table 4.1-9 of the APP provides the design information for the ponds which indicates that all the ponds are lined. Section 2.6 provides various contingency actions including: freeboard exceedance, conditions other than freeboard, alert levels related to liner leakage, overtopping, inflow of unexpected materials, and liner failure, containment structure failure, or unexpected loss of fluid. No changes to the APP are necessary.

Groundwater Modeling Report -Appendix I

Clear Creek Associates modeled the regional hydrogeology using the MODFLOW computer code (CCA 2016, Appendix I). MODFLOW is a program that solves the equations of groundwater flow by completing a water balance among model cells. A model cell is a three-dimensional rectangular volume in which various properties of the geology are described. Those properties usually are an average of properties that could vary at scales much smaller than simulated with the cells. The modeler inputs the model domain structure, material properties, and known groundwater flow inputs to the model which solves the equations specifying the water level or pressure over the model domain and the groundwater discharges to various points. The model domain is the aquifer volume being modeled.

Excelsior relied on the numerical groundwater model to show that their project will control the hydraulic gradients and prevent contaminants from escaping to the surrounding aquifer. This section reviews the model and shows that it is not sufficient evidence to show there will be no escape of contaminants.

Model Structure

Solving the equations completes a water balance among model cells that describe parts of the domain. For this site, the cells range from 300 feet to 75 feet square, with the finest discretization in the well field (Figure 8), which allows for more detailed calculations. The model domain extends from the Little Dragoon Mountains in the northwest to the Dragoon Mountains in the southeast (Figure 8).

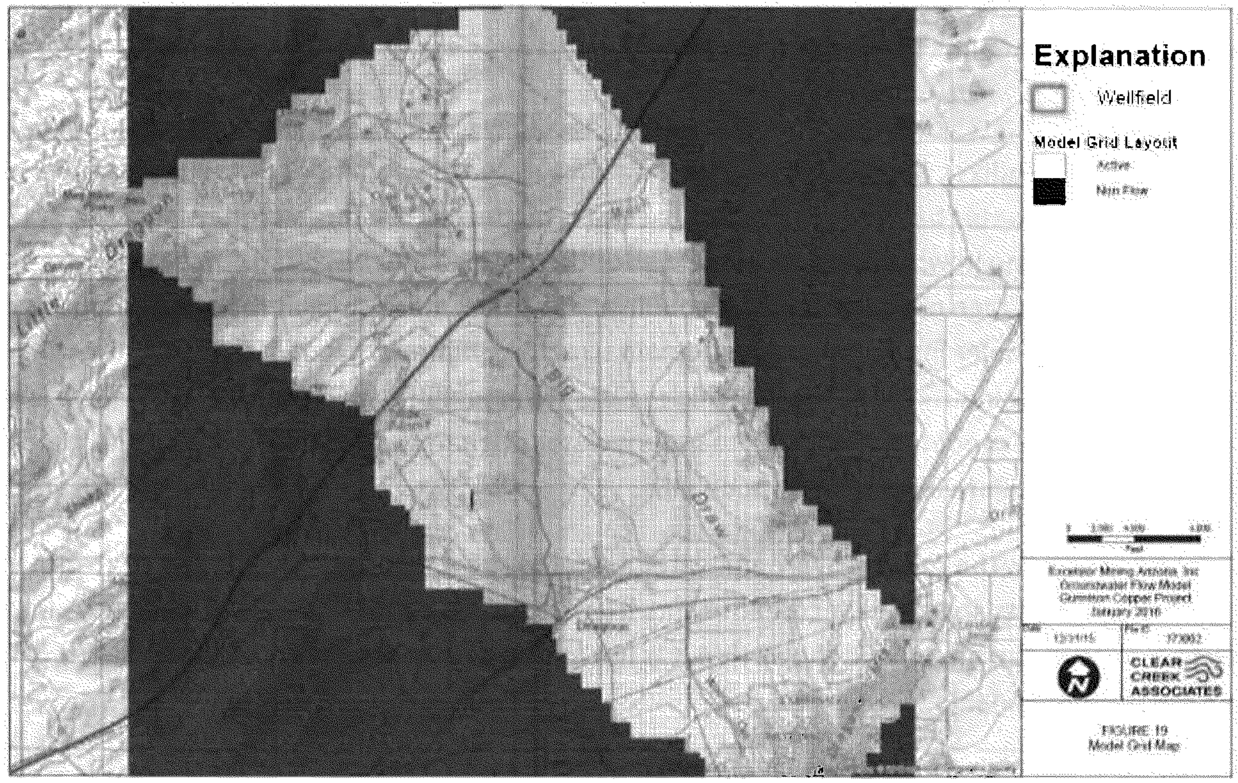


Figure 8: Figure 19 from CCA (2016) Appendix I showing the groundwater model grid.

Vertically, the geologic formations are divided into seven layers. Layer 1 varies from 85 to 1648 feet thick, while layers 2 through 5 are 300 feet thick, and layers 6 and 7 are 400 feet thick (Figure 9). All layers are bedrock in the west where bedrock outcrops in mountains and layer 1 is basin fill everywhere other than at the outcrops (p 18). Layers 2 through 4 have decreasing amounts of saturated alluvium corresponding with the deep fill east of the project. The lower portion of all layers is horizontal, meaning that formations dip through the layers (Figure 9). Layer 1 is unconfined, layers 4 through 7 are confined, and layers 2 and 3 are convertible, meaning the model would treat them as either aquifer type depending on the simulated water level. The layers are much too thick to accurately simulate the flow around the injection/collection wells which would depend on fracture zones.

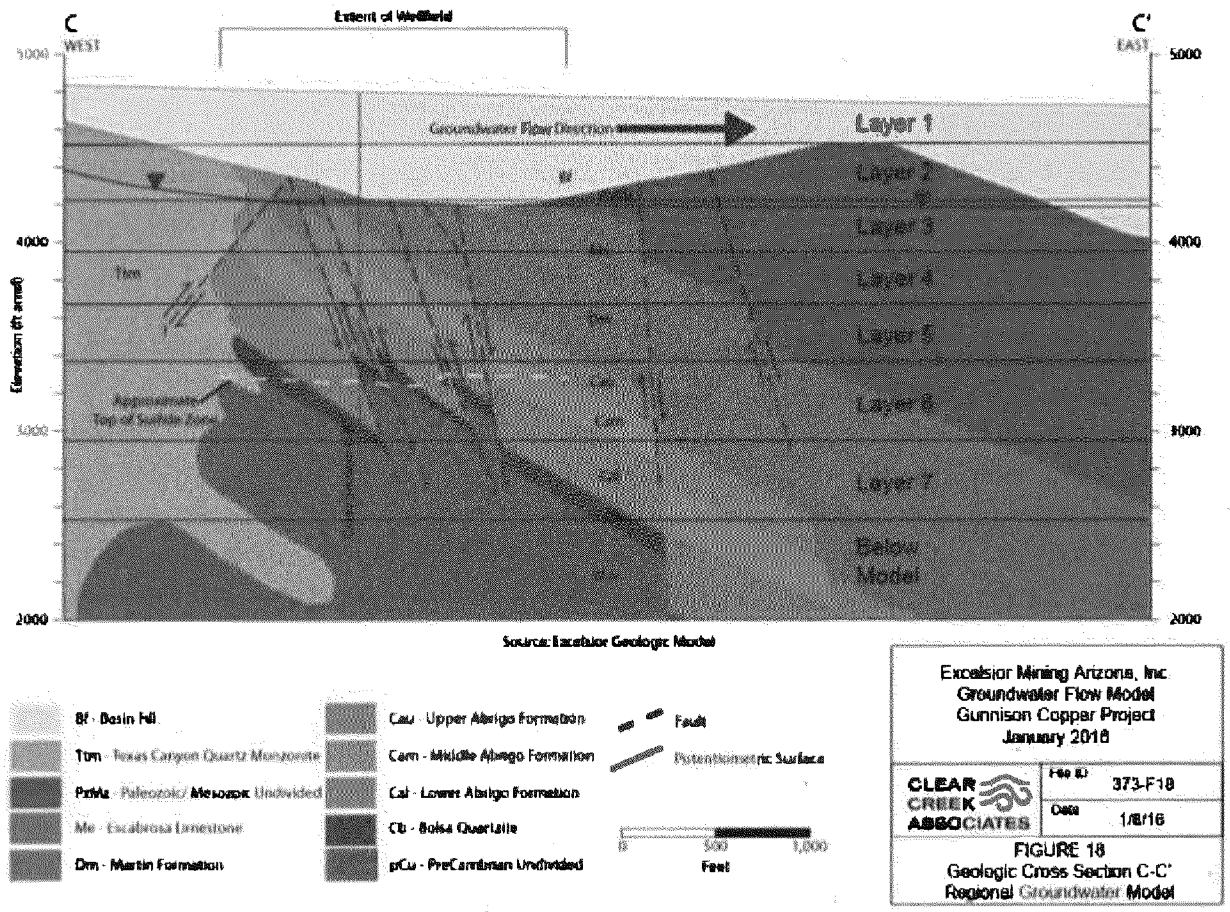


Figure 9: Figure 18 from CCA (2016) showing the model layers and geologic formations dipping east through them.

The model includes neither horizontal anisotropy or an orientation of grids to align with the fracture orientation, which would facilitate simulation of horizontal anisotropy (Appendix I, p 18). This is a failure to consider the preferential flow potential parallel to the fracture orientation (see the discussion above regarding horizontal anisotropy).

Boundary Conditions

The water balance and flow equations require boundary conditions where either the water level, a groundwater flow, or both are specified. There are no flow boundaries on the north, west and south bounds of the model domain which generally coincide with a topographic and expected groundwater divide, as is appropriate. A no flow boundary is one through which groundwater does not flow and generally means that groundwater flow is parallel to the boundary. Recharge is the boundary in this model which provides the flow through the aquifer system. The estimated total recharge was 738.2 af/y for the entire model domain after calibration, which the modelers divided into Walnut Wash and Big Draw areas (CCA 2016, Appendix I, Table 4). This is discussed in more detail below.

Appendix I Figure 30 shows constant head boundaries for flow to the east. There is one to the north where Walnut Wash leave the domain and one the south through the gap where Big Draw leaves the domain. Because the boundary on the north is much longer than the boundary on the south, there may be a tendency for flow to go north, although the conceptual flow model does not justify this. The outflows are with constant head boundaries through layers 2 through 7, with the same head in each layer (p 20). This means the modeling does not impose any vertical gradient at the model boundary. Because the report does not provide water balance data, it is not possible to assess the reasonableness of the constant head boundaries through which groundwater flow leaves the model domain.

Modeled Material Properties

The model includes material properties, which are generally set by calibration guided by prior knowledge of the formation properties. The prior information was the pump tests and transmissivity estimates discussed above. This section discusses the modeled material properties. The modelers establish hydrologic parameters using the parameter zone method, meaning that a given geologic formation was assigned a series of parameter values. Excelsior assigned the parameter blocks and values based on their combined geologic/fracture intensity model, as critiqued below.

The final parameter values were set by calibration, described below, and the Initial values used for calibration were based on correlation between fracture intensity and hydraulic conductivity. Excelsior estimated fracture-intensity for 100 by 50 by 25 feet thick blocks within and near the ore body. The geologic model was incorporated into finite difference model cells. Outside the ore body, material properties were based on mapped geologic units. Each modeled material was divided into five property zones to specify K for the formations in the model, based on the conductivity/fracture intensity relationship (CCA 2016, Appendix I, p 19). Outside the ore body, a sixth property zone was used to simulate properties that were not as fractured as within the ore body. The fracture intensity was assumed lower away from the ore body, which resulted in a lower simulated conductivity away from the ore body. This has the effect of containing the simulated effects of mining to the project site.

The fracture intensity is much higher in the areas with significant faults, as shown on Figure 10. Faults trends just west of north through the domain south of the project site and curve to a more northwest trend near the site. The yellows and reds on the fracture intensity model is the area of higher fracture intensity. Fracture intensity is much lower west and east of the project area. A model fit shows that conductivity ranges from 1 to about 10 ft/d for the higher fracture intensity (Appendix I, Figure 16).

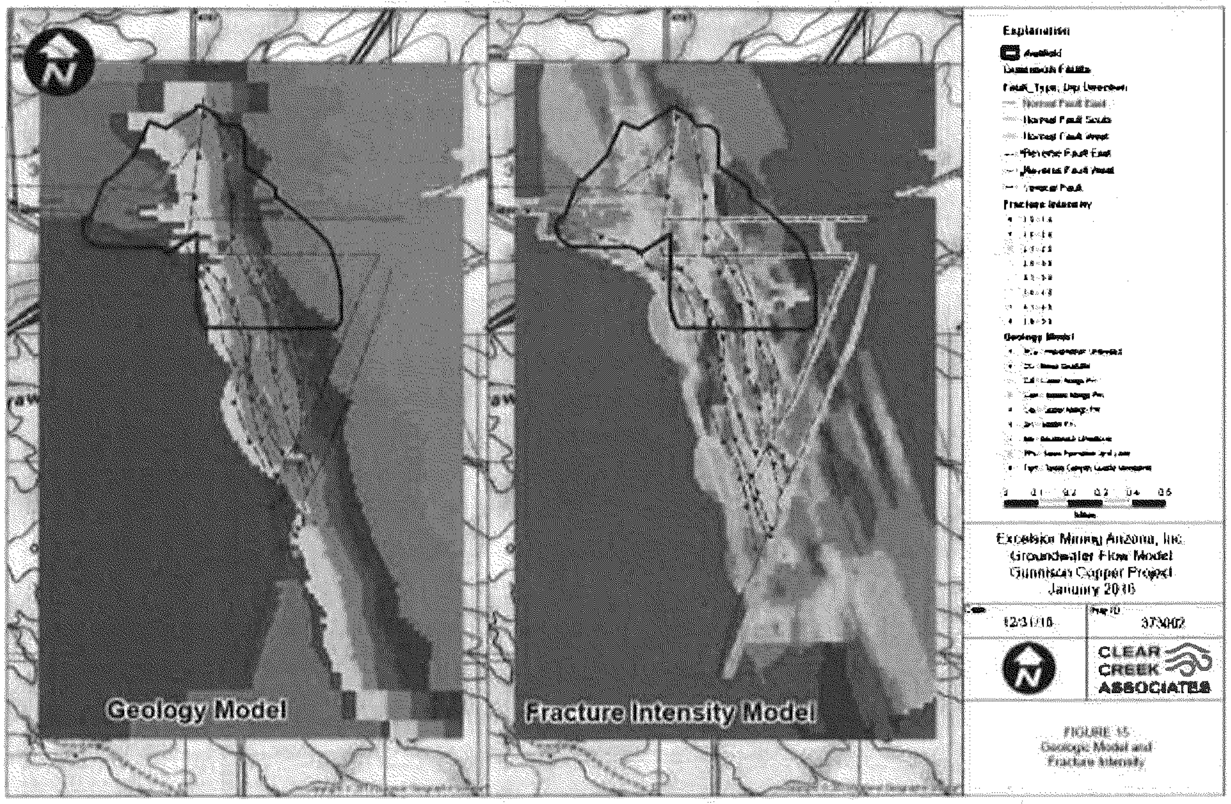


Figure 10: Figure 15 from CCA (2016) Appendix I showing the geologic and fracture intensity model.

Appendix I, Table 9 summarizes the hydraulic conductivity values by formation type and fracture density. Fracture density is rated from 1 to 5 with increasing density corresponding to increasing values. A 0 was used for formations away from the areas with fracture intensity measurements. There are at least three major problems with the way the model handles conductivity based on the presentation in this table.

1. Permeability, and therefore conductivity, should increase with fracture density, but Appendix I, Table 9 has many exceptions which are not logical. Most formations have an example of higher fracture density coinciding with lower conductivity.

ADEQ response to Comment #6.25
In Table 9, Appendix I, fracture intensity values of zero (0) were set in the model for regional data outside the wellfield. This was for coding purposes only as fracture intensity logged by Excelsior only ranged from 1 to 5. Therefore, the value zero does not follow the typical fracture intensity/conductivy relationship. Texas Canyon, Undifferentiated Paleozoic Rocks and Naco Formation were used for regional calibration and the hydraulic conductivity zones representing them were adjusted during calibration of the steady state model.Even so, these formations generally show the appropriate relationships. As stated in ADEQ response to Comment #5.1, Excelsior shall reevaluate the groundwater flow model after the first year of operation in Stage 1.

2. With the exception of basin fill, there is no simulated difference among Kx, Ky, and Kz. This means the model would treat conductivity in all directions for all bedrock formations equally. The very nature of fractures is they tend to be more prominent in a primary direction, so this table violates that precept. Due to bedding in sedimentary rock (most of the formations), there is also tendency for flow along the dip rather than perpendicular to it. Both would cause $Kx \neq Ky \neq Kz$.

   ADEQ response to Comment #6.26
   ADEQ agrees that Table 9 does not include differences in Kx, Ky, and Kz. However, the model does take directional differences in permeability into account by assigning hydraulic conductivity horizontally and vertically directly from the mine geologic model which is based upon detailed corelogging. In this way, the model accounts for differences in horizontal and vertical flow in a more realistic way than by introducing anisotropy through cell-by-cell variation of Kx, Ky, and Kz.

3. The conductivity values are commonly the same depending on fracture intensity rather than formation type. For example, for fracture intensity 4 and 5, K = 10 and 65 ft/d, respectively. There are other examples. This suggests there have been too few aquifer tests to justify discretizing among so many formation types. It also means there are no differences among geologic formation types.

   ADEQ response to Comment #6.27
   ADEQ does not agree that there has been too few aquifer tests. The hydraulic conductivity for the sedimentary units are the same for Fracture Intensities 4 and 5, except for the hydraulic conductivity for Fracture Intensity 4 in the Naco Formation. In the geological model, fracture intensity is not assigned based on the formation type, but instead is based on what was observed in the drill core, independent of formation. The separation of formations in developing the hydraulic conductivity distribution of the model was done to allow visual distinction of the different formation in the model and to allow refinement of calibration locally, if needed. An example of local refinement during calibration is the fracture intensity 4 unit provided for the Naco Formation.

4. There are six zones for each geologic formation. The text claims the formation outside of the ore body is not mapped with respect to fracture intensity, represented by zone 0 for each formation on the table. They claim that "fracture intensity appears to be strongest in the area of the ore body" (Appendix I, p 19), therefore the conductivity outside the ore body is usually lower than within the ore body. However, they did not sample outside the ore body (Id.), so it is no data or evidence to support this claim. Table 9 does not confirm this statement because there are examples of the intensity 0 (outside the ore body), having a higher conductivity than within. If the model has higher K within the ore body, it would simulate less head drop and easier flow through the ore body than around it.

ADEQ response to Comment #6.28
The average fracture intensity from geological logging in and adjacent to the ore body is just over a value of 2. Although sporadic drill core from more distal locations shows significantly lower fracture intensity this was not incorporated into the model. Instead, to be more conservative, the regional rocks were coded to a fracture intensity of zero (0) with a hydraulic conductivity approximately equal to the average for the ore body and immediate surroundings. This will be evaluated pursuant to ADEQ response to Comment #5.1.

5. Appendix I, Table 11 purportedly includes calibrated K values, but shows values as high as 65 ft/d, whereas the figures showing calibrated K zones with values (App I, Figures 21-27) do not show any values greater than 10 ft/d. This is a substantial error in the presentation of the model parameters.

ADEQ response to Comment #6.29
ADEQ does not agree with the statement. Table 11 shows the groundwater model calibration results. It only includes observed and computed groundwater elevations. It does not include hydraulic conductivities.

The conductivity values for each material zone (App I, Figures 21-27) are the result of the steady state calibration, details of which are described below. Values for layer 1 show the meeting of the bedrock outcrops on the west with the basin fill on the east, with low values, less than 0.01 ft/d matching with higher values, 1 to 10 ft/d for the fill (Figure 10). The low K for bedrock under the outcrop extends down through all seven layers (App I, Figures 21-27). This low K area causes the steep groundwater contours west of the well field. The high values for basin fill, 1 to 10 ft/d, shown in red running north-south through the valley east of the project, extend to layer 5 to represent the full thickness of the fill (Appendix I, Figures 21-25), primarily causes the flat groundwater contours seen in this area. At depth, bedrock K is low, with K less than 0.01 ft across the southeast portion. At shallower layers, higher K from 0.5 to 1.1 ft/d provides a conduit for flow to reach the boundary outlet from the domain in the southeast.

Because of the fracture intensity modeling, the model has very detailed parameter zone models within the ore bodies, as can be seen from detailed observation of the ore body on the parameter zone maps for each model layer (App I, Figures 21 -27). Most of the well field area has K equal to 0.5 to 1.0 ft/d, with some intermittent higher and lower cells that resulted from the detailed fracture intensity modeling. The west half of the ore body has the most detailed parameter zones, as may be seen in the magnified portion of App I Figure 22 shown in Figure 11 for layer 2. The complicated fracture intensity model may represent the fractures associated with faulting, as shown in Figure 10.

Figure 11: Magnified portion of Appendix I, Figure 22 showing the details of the parameter zones on the west side of the ore body, and to its south.

Recharge is a specified flux boundary to the model, meaning the modeler sets a constant value that is forced to enter the model at a given point. It is the boundary that inputs water to the model. Recharge is distributed around the model domain jointly with the setting of hydraulic conductivity, because the conductivity controls groundwater flow through the model domain and sets the observed water levels. The modelers assumed an average 12.5 inches of precipitation with 3% becoming recharge, "based on other similar modeling studies" (Appendix I, p 12). The report does not reference those other modeling studies or provide any support to the use of 3% in this area. The modelers adjusted the recharge percentage to 2.8% of annual precipitation, presumably due to an inability to force the recharge into the model without using unreasonably high conductivity values. Conductivity controls the ease with which recharge enters the model domain, and during a steady state model simulation, the model would establish the groundwater level at that necessary to create the gradient necessary to force the water into the domain. If the water level is unreasonably high, the modeler has the choice of changing the amount of water being forced into the domain or changing the conductivity to ease the entry of the flow.

Higher flow rates require higher conductivity values for the simulated head values to equal the observed values. Model calibration would establish the conductivity along these flow paths, all else being equal, to be higher to allow a larger amount of water to flow through. If the recharge amount is either too high or too concentrated in one area, the conductivity would therefore also be artificially too high.

As part of calibration, the modelers distributed the total recharge around the model domain (Figure 12). The noncolored area on Figure 12, which is most of the domain away from the mountains and washes, represents recharge less than 0.012 in/y.

The concentrated recharge may significantly bias the model results. The large zone in orange, west of the project site in the Little Dragoon Mountains, is recharge from 1.2 to 2.4 in/y (Figure 12). Recharge would enter the groundwater in this mountain block only if the geology is highly fractured at the surface, otherwise the area should mostly generate runoff. Much of those mountains have the second highest conductivity values (Figure 13), possibly due to the calibration.

Walnut Wash is a substantial drainage which flows east from these mountains, which indicates there is substantial runoff from the mountains. The model simulates from 0.55 to 6.6 in/y near Walnut Wash west of and within and north of the north quarter of the wellfield. The area is almost 2000 feet wide and over 6000 feet long. The recharge rate into the model domain through the Walnut Wash area is very high, the product of the rate and area shown in red. Most other areas that represent washes are simulated with recharge from 0.12 to 0.5 in/y (green).

Only the smallest recharge rate is used for recharge in the Dragoon Mountains in the southeast. Even if the geology is not conducive to distributed recharge, there should be runoff that leads to mountain-front recharge.

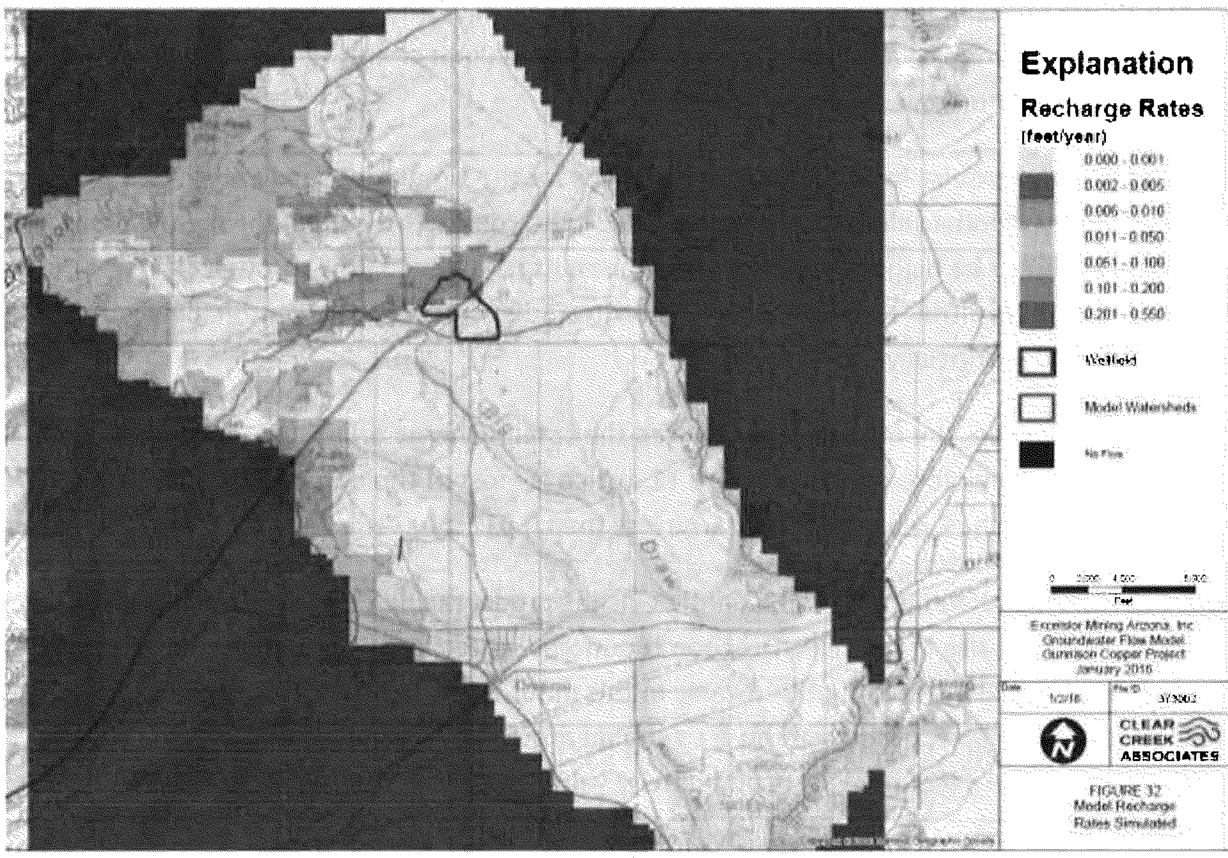


Figure 12: Figure 32 from CCA (2016) Appendix I showing the calibrated steady state recharge rates around the model domain.

As a result, the calibrated conductivity near the wellfield could be artificially too high. This would cause simulated flow through the area, both regional flow and injected flow to be channeled through large preferential flow areas which would prevent it from flowing away from the well field. Essentially this recharge distribution could channel flow away from Dragoon and other areas, thereby causing the model to not estimate impacts to groundwater users near Dragoon.

The recharge distribution used by the modelers forces most of the recharge for the entire domain into the ground in the mountains just west of the project site or along the wash just west and north of the project site. This recharge distribution would cause much higher flows to emanate from that area to the outflow points. Some of the area under the wash has some of the lowest conductivity values, which may be due to the high groundwater elevations west of the site. It also may cause some of the recharge to flow initially to the north where the conductivity is lower.

The low K in model layer 1 west of the well field (Figure 13) coincides with the high recharge in the Walnut Wash (Figure 12). This causes the higher groundwater ridge and steep slopes seen in the modeled steady state contours (Figure 14). Much of the remainder of the high recharge zones west of the project coincides with higher conductivity material in layer 1.

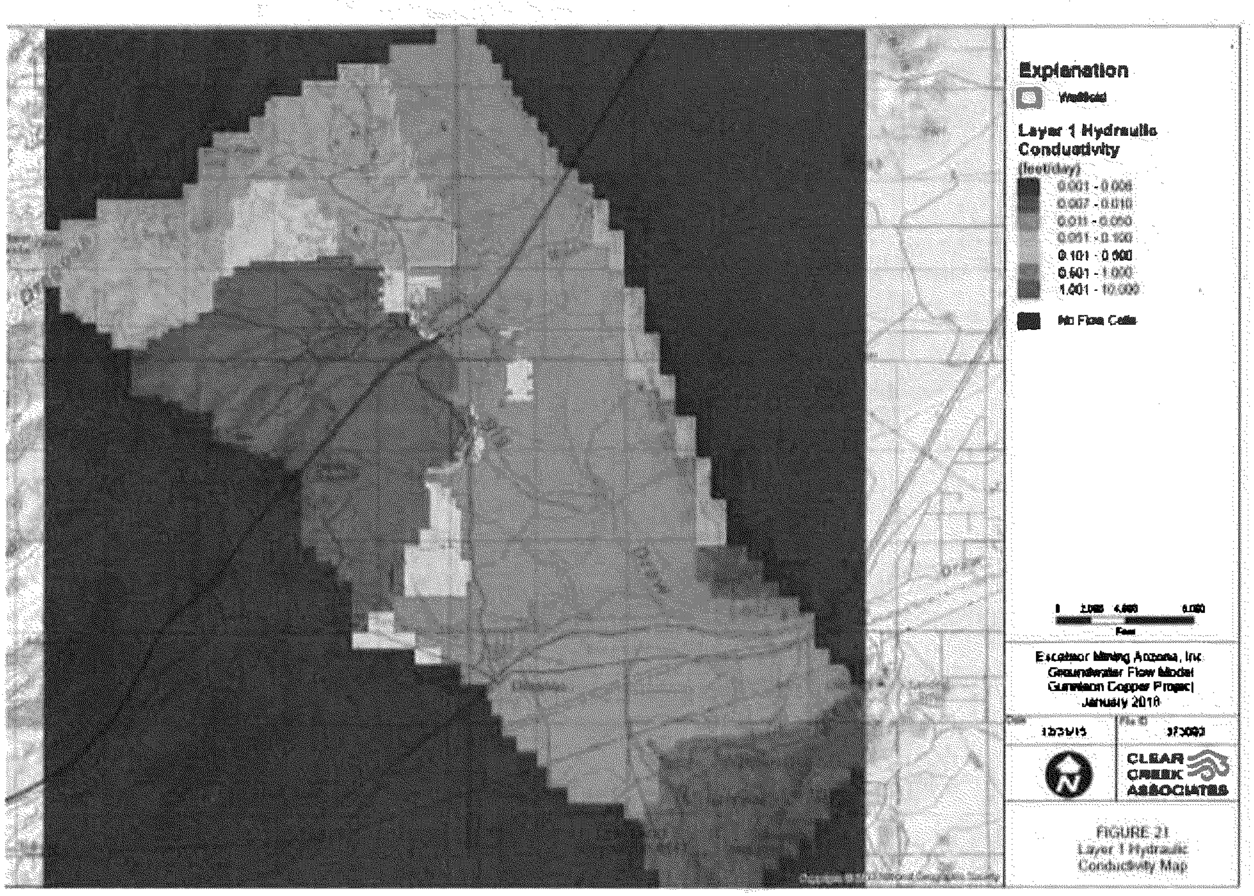


Figure 13: Figure 21 from CCA (2016) Appendix I showing conductivity in model layer 1, the uppermost layer in the model.

Vertical K equals horizontal K for all bedrock, so there is no resistance to deep groundwater flow. There is no discussion of vertical circulation as part of the conceptual model, meaning the modelers had no expected natural vertical circulation of groundwater flow. It is likely that the numerical modeling allows an unrealistic amount of water to flow at depth through the domain because of vertical K equaling horizontal K, especially at depths below layer 1. Appendix I does not provide water balance data, either for the entire model or for individual layers, as is customary for the presentation of groundwater model results (Anderson and Woessner 1992). This limits the ability of the reviewer to assess how realistic is the simulated groundwater flow.

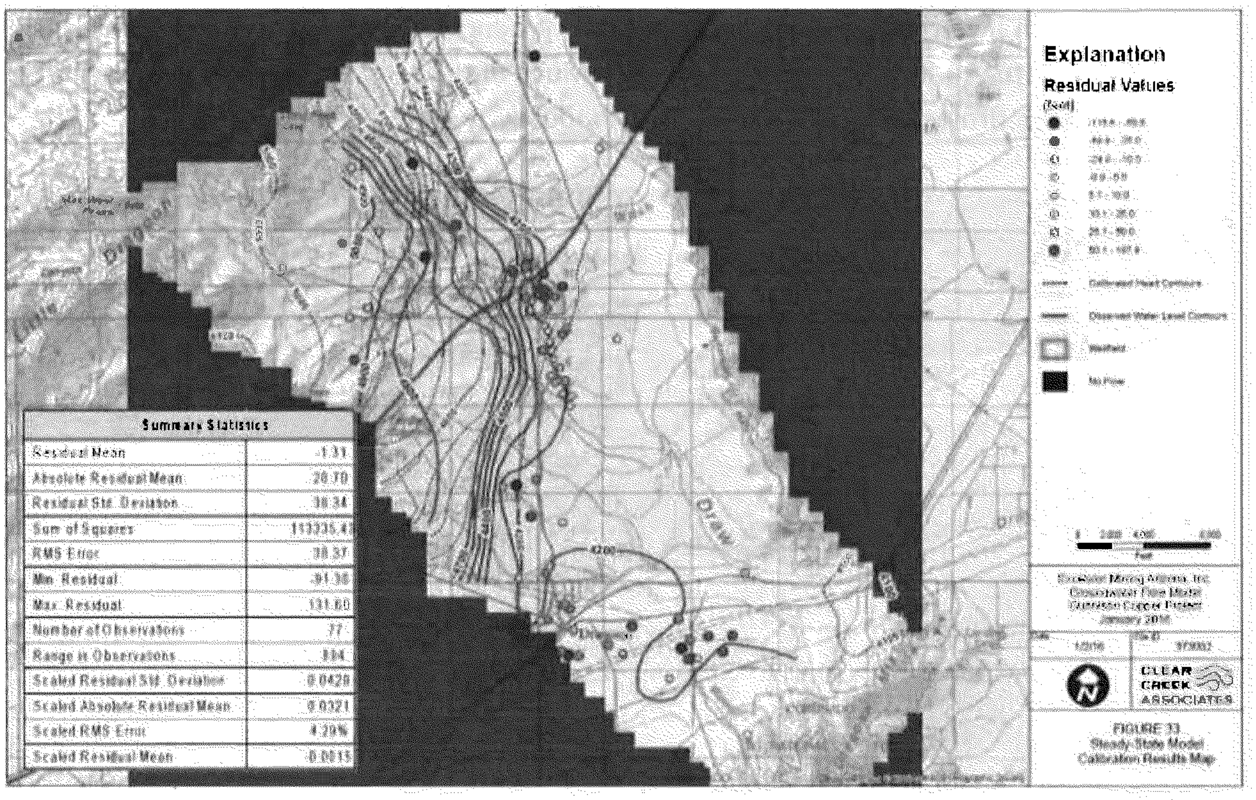


Figure 14: Figure 33 from Appendix I showing groundwater elevation contours, residuals at observation wells, and residual statistics.

Storage properties of the material control how much water is released for a unit change in pressure or head. It effectively controls how fast the aquifers release groundwater to pumping. Specific storage was set equal to 0.00001/ft, which ignores the vast variability in values found during the pump tests.

Faults and fractures play a large role controlling the flow through the model (CCA (2016), Appendix I, p 15). The model uses a horizontal flow barrier (HFB) through the middle of the wellfield area to simulate a large head difference observed in the wells (Figure 15). The head is variable throughout the area, and there is a lot of variability even within blocks as defined by the faults or HFB. For example, the difference between NSD-028 (4437) and NSM-013 and NSD-027 (4391 and 4376) suggest significant vertical gradients within the block, which suggests the model uses an HFB in appropriate areas. A NW to SE HFB would seem more reasonable to separate NSD-026 (4423), NSH-007 (4427), NSH-008 (4425), and NSD-032 (4437) from NSH-010 (4189), NSH-031 (4198), NSH-032 (4190), NSD-037 (4296); NSH-012 is labeled 4747 but its color code suggests it should be 4147. The distance between these groups is generally around 1000 feet.

Figure 15: Figure 31 from CCA (206) Appendix I showing the horizontal flow barrier and April 2015 water levels near the barrier.

Model Calibration

Calibration is the process of matching simulated and observed head levels by adjusting the material properties to adjust the simulated heads. Calibration also involves matching simulated and observed groundwater flow rates, if there are observed rates available. Steady state calibration occurs assuming the system is at steady state. Because there is little stress in the aquifers near the proposed project, the system currently is close to being in steady state so matching average water levels would be considered steady state calibration.

The description of matching simulated with observed heads (Appendix I, p 21) suggests the simulated heads were the water table values from the simulation. This means it is the water level in the uppermost active layers. Model layers for which the bottom of the layer is above the water table are inactive. Because the model allowed layers 2 and 3 to be convertible with respect to being simulated as confined or unconfined, the uppermost aquifer could not be confined because once pressure in one layer goes above the top of the layer, the layer above becomes an unconfined layer. Thus, the calibration appears to have compared simulated unconfined conditions in the uppermost active layer in the model with either the water table of an observed unconfined aquifer or the pressure level of a confined aquifer. In other words, the model simulates saturated conditions above a confining layer, which is inappropriate. In areas where the flow is known to be confined, the layer with the flow should be set as confined so the head in the layer may be higher than the top of the layer without flow entering the layer above.

Figure 14 shows simulated and observed groundwater contours and residuals resulting from the final calibration. A residual is the difference between simulated and observed values. The simulated heads have a much more consistent gradient and resemble a surface much more than the observed heads. This probably reflects how the model layers represent average values over several fracture zones whereas the observation wells are monitoring different fracture zones. Simulated contour 4200 ft lies a couple thousand feet east of the observed 4200 ft contour which means the simulation results in a potentiometric surface above the observed.

The residuals through the wellfield area transition from high positive values, 50.1 to 137.9 with red circles to high negative values, -115.5 to -50.0 with blue circles over a short distance. The simulated potentiometric surface resembles an eastward dipping plane through a water table that is both far above and far below the plane. This could be the result of a flow barrier that causes the actual water levels to drop but is not included in the model or trying to match observed water levels from aquifers that are not connected. The rapid change in residuals across the site indicate the conceptual model for the area is inaccurate. It could assume connectivity among formations that does not exist, not considering horizontal anisotropy which would cause flow to trend in a certain direction and drop faster in other directions, or assuming more recharge which causes conductivity values that are generally too high. If the fractures trend NW-SE, as noted above, simulated east to west flow would be at an angle to the preferred direction based on fractures.

There is little data for transient calibration, which would attempt to match observed water level changes due to a stress applied to the aquifer by changing storage coefficients. The modelers calibrated to data for a pump test at NSH-015, which included a series of four short-term pumping rates followed by a several-day period of constant pumping at 85 gpm. Drawdown at NSH-019 had been predicted to be 4.89 feet but the model simulated just 0.01 feet (Figure 16). This is due to the fracture-dominated flow system and that drawdown depends on the observation well being in the same fracture system as the pumping well.

These results demonstrate future problems that will occur with the system. Injection of leachate into a fracture zone that does not have a collection well or a control well will allow flow to exit the system. Figure 16 shows however that there is likely an inappropriate model flow barrier between NSH-015 and NSH-019 since the observed drawdown, as noted 4.89 feet, occurs about 500 feet east of the simulated 1-ft drawdown contour. The simulated material properties may not connect high K values to create an actual zone. The model cells are much larger than any fracture zone and the fracture intensity would depend on the observed fractures within the cell.

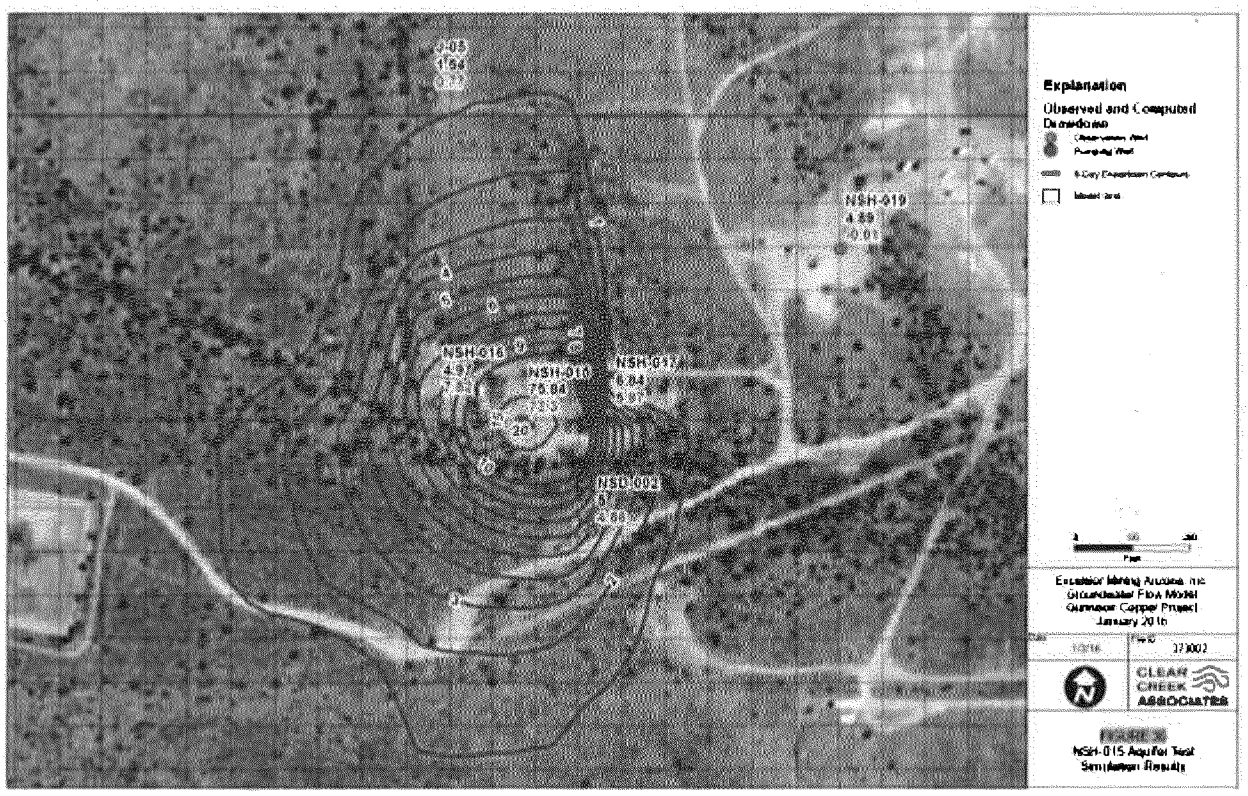


Figure 16: Figure 36 from Appendix I showing the drawdown from the pump test at well NSH-015.

As critiqued above, the calibration involved adjusting recharge as well as material properties. This would result in a nonunique model, meaning there are an infinite number of combinations of material properties and recharge that could result in the same simulated head values (the only observed values being matched for calibration). This may be seen from Darcy's Law, which relates flow rate to conductivity and gradient. For a given gradient (defined by the head values), K would vary as flow rate (flux) varies. If flux changes, K changes as well. If the K value is known in advance, the flux can be determined using Darcy's Law. If both K and Q can be adjusted, there are an infinite number of solutions to yield a measured gradient. By adjusting material properties and flux within a groundwater model, the resulting model is nonunique because there are an infinite number of property values than can match the observed heads. Based on the information regarding calibration of recharge and material properties at the same time in Appendix I, the Gunnison model is nonunique. It is accurate only if the recharge estimates are accurate but there are no measurements of recharge. The problems with the model being nonunique are that the parameters values may be grossly wrong. This could affect the predicted results of the project simulations and lead to inappropriate assumptions about the operations of the model, especially on a regional basis.

By this, I mean that even during operations, Excelsior will adjust injection and collection rates to meet the needs within the well field; elsewhere, the model predictions could be very inaccurate due to inaccurate parameters.

Model Recommendations

The previous sections provided comments on numerous aspects of the model, but there are two overriding recommendations which would improve the model and improve most ofthese comments.

- The model should be improved with a better conceptual flow model, that better accounts for the fracture system near the well field due to the faults. It should better simulate horizontal anisotropy as caused by the fracturing. It should have more layers to better simulate the steps in the observed water table.

  ADEQ response to Comment #6.30
  ADEQ will require Excelsior to update the conceptual model, as appropriate, along with the groundwater flow model each time the groundwater flow model is reevaluated per ADEQ response to Comment #5.1.

- The conceptual model should also include estimates of discharge from the model domain. these estimates should be targets in the calibration, which would make the model more unique.

  ADEQ response to Comment #6.31
  Please see ADEQ response to Comment #6.30.

Simulation of the ISL System

The ISL system involves injection and recovery of acidic solutions within the ore body, using four collection wells for each injection well. However, collection wells will be used with adjacent wells, as shown in Figure 17. Injection/recovery rates will vary and may be as high as 100 gpm from individual wells (Appendix I, p 25). Overall, the simulated injection is several thousand gpm for the first ten years and more than 20,000 gpm during the last seven years. most of the water would be recirculated, so this does not represent an ongoing consumptive used.

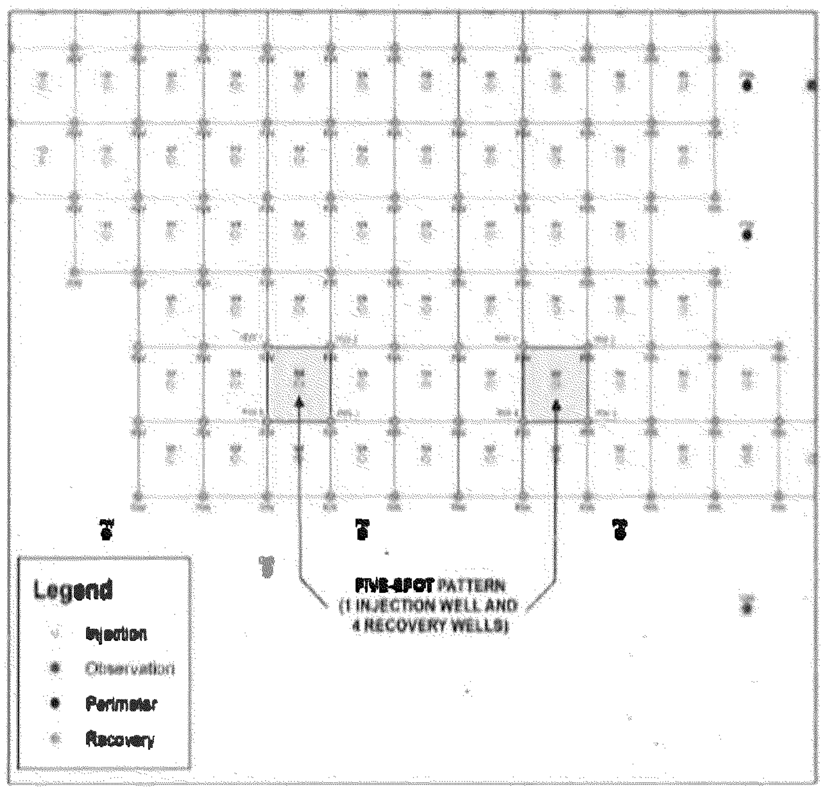


Figure 17: Portion of Figure 44, Appendix I, showing the five-spot pattern for injection/recovery wells.

The model simulates pumping the hydraulic control wells that surround the well field, but does not simulate the 5-spot injection/collection regime within the well field (Figure 18). The hydraulic control well pumping was imposed on the steady state flow simulated in the calibration. Simulations ran for 23 years, simulating each year as a new stress as new blocks of injection/collection wells come on line (Figure 18). Pumping rates extend to only about 190 gpm total. Only hydraulic collection wells downgradient from operating injection/collection wells were operated during any given year. As may be seen from the annual drawdown maps (Appendix I, Figures 48 – 56), drawdown centers on the hydraulic collection wells and the model simulated no groundwater level changes near the area being mined.

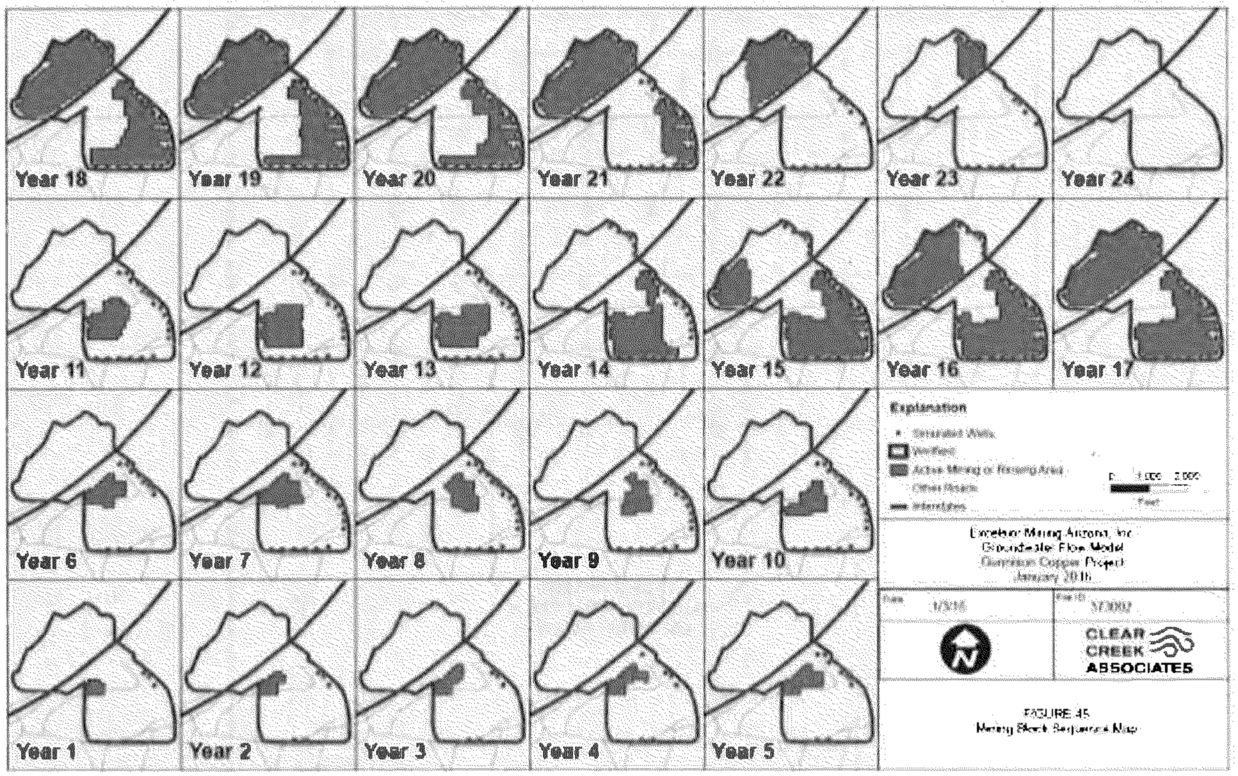


Figure 18: Figure 46 from Appendix I showing the progression of mining, in blue, and simulated hydraulic control wells.

The model simulated the transport of contaminants from the mining areas using particle tracking as implemented by the MODPATH model within MODFLOW. The modelers released contaminant particles into the model at the edge of the mining areas (Figure 19) at various times based on the progression of mining. Figure 19 also shows the simulated hydraulic control wells. Being downgradient from the particle release points, the model simulates all released particles that are captured by the hydraulic control wells (Appendix I, Figures 57 – 59).

Particle track modeling shows that released contaminants would not escape the well field, but the modeling provides little confidence in the results. The particles follow the simulated flow paths, which are average flow paths that do not account for preferential flow paths through fracture zones.

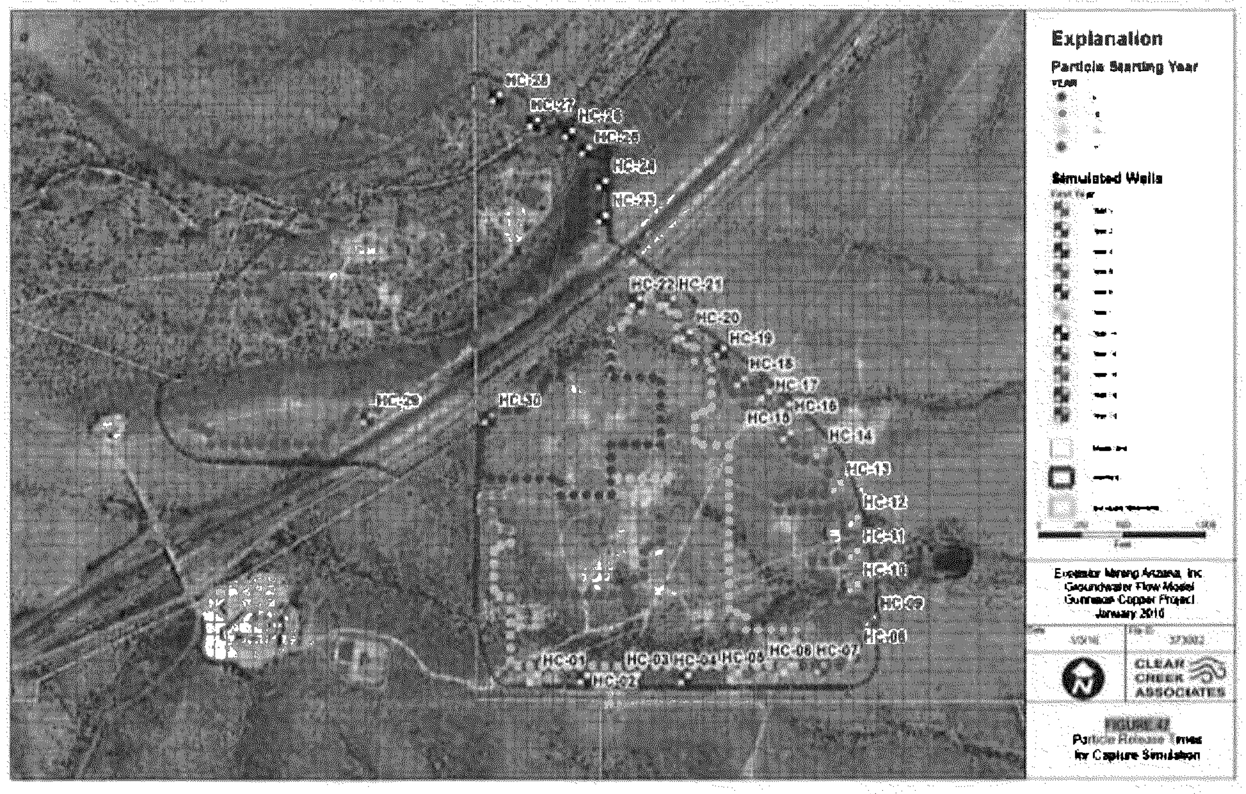


Figure 19: Figure 47 from Appendix I showing the location and times that contaminant particles are released for simulation.

The report presents the results in a time series of drawdown maps and particle tracking for contaminants released at various points within the well field. The drawdown maps show the entire well field would eventually have drawdown. This drawdown represents an amount of water that has been removed from storage and would be the difference between injection collection. Drawdown due to the project is the difference between the simulated groundwater level at any given time in the future and the baseline, the steady state water level.

Not all areas within a drawdown cone are areas in which the groundwater flow is toward the middle of the cone. If the baseline groundwater contours dip steeply in one direction, a drawdown may just be a change in slope and the flow may still be away from the cone. Figure 20 shows groundwater velocity vectors (arrows showing direction with the length of the arrow proportional to the speed of groundwater flow) and the groundwater contours (not drawdown) for year 21 (not accounting for injection/collection wells). On the north, west, and south, the groundwater contours naturally slope steeply toward the well field, but in the east and southeast the contours define a relatively flat surface. The surface is so flat that small changes would could cause directional changes in the velocity vectors. The contours in Figure 20 are based on the average head for a specific cell. There is a 4170 contour around the southeast corner of the wellfield delineates a trough in the contours, meaning that simulated flow is to the center of the trough. Based on the estimated capture zone line, the yellow line on Figure 20 which shows the position of the groundwater divide, the water level is relatively flat throughout the southeast quarter of the wellfield. The mound in the water table represented by the capture zone line is only a few feet higher than the water table in the southeast corner of the project. The pressure at different levels in the groundwater, from the water table surface to a point below the well field, could easily vary from that estimated by consideration only of the water table due to different transmissivity flow paths. Contaminants could escape from the hydraulic control through preferential flow paths through the mapped divide because the average heads in the model cells may not represent actual heads in the fracture zones.

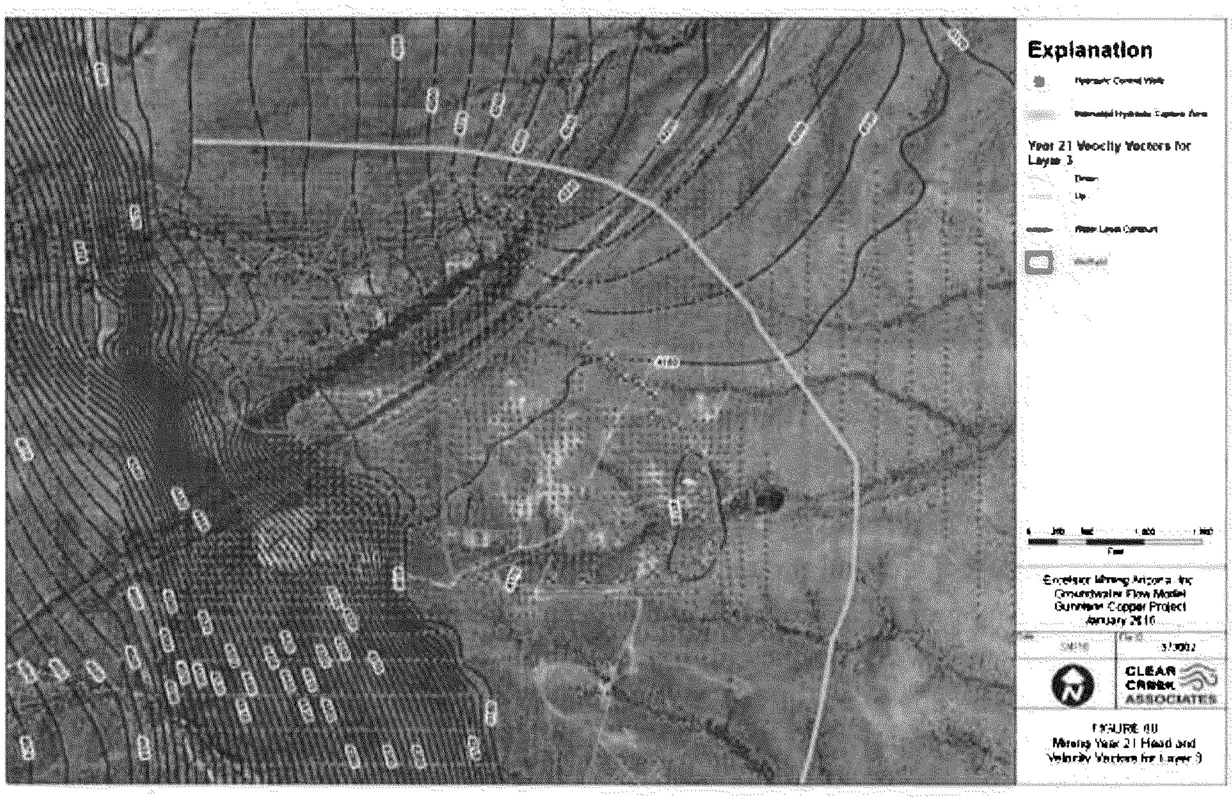


Figure 20: Figure 60 from Appendix I showing the simulated groundwater contours and groundwater velocity vectors for model layer 3, year 21, the end of Stage 3 mining.

The simulation of particle capture and release is not an accurate area, for the following reasons:

- Drawdown throughout the mining area caused by pumping only the hydraulic control wells is unrealistic. The injection wells would be injecting much more fluid into the system than the hydraulic control wells removed. Of course, the collections wells also remove more, but due to the high injection rates and heterogeneities in the well field, there could easily be high pressure injection into flow paths not otherwise captured by collection wells. The combination of injection and recovery wells would create a combination of local mounding and drawdown. Due to the volumes and gradients resulting from the injection/collection wells, the hydraulic control well pumping could be overwhelmed. Without simulating the injection/collection wells, this model does not provide reliable information regarding the effect of the injection/recovery system on local or regional flow paths.

ADEQ response to Comment #6.32
ADEQ does not agree that discretizing the model to have individual cells for each well is required. The injection and recovery rates within the mine block are to be approximately equal so the water level is maintained. Additional evaluation was conducted in the two Excelsior responses to ADEQ Comments (see ADEQ response to Comment #6.6).

- Contaminants in the model would be released at the edge of the interior well fields (Figures 18 and 19), but they would not be under pressure as they will be during operations. During operations, the particles would be released at the beginning of a pressurized stream that would cause the particle to move faster than simply being placed at given levels in the aquifer.

ADEQ response to Comment #6.33
ADEQ does not agree. Excelsior evaluated how particles would behave when released at the beginning and end of mining certain mining periods. Excelsior in April 2017 Response to ADEQ comments provided additional evaluataion of how particles would move if there was an excursion. The following figures shows how far an excursion would go under certain conditions and whether the excusion would be recovered. The figures are as follows: Figure 8-2 "Closure Strategy Particles and Well Rates Mining Year 1", Figure 8-3 "Closure Strategy Containment after Shutdown Mining Year 1", Figure 8-4 "Closure Strategy Pumping Rates for Wells Mining Year 5 Closure", Figure 8-5 "Closure Strategy Drawdown after Year 8 Mining Year 5 Closure", and Figure 8-6 "Closure Strategy Particles Traces Mining Year 5 Closure" (Please see the attached figures below in ADEQ Response Figures). In addition, the purpose of the IMWs is to evaluate groundwater flow model predictions and evaluate potential fluid channels during operations to prevent large excursions from reaching the POC wells.

- The model simulates pathways that are at a minimum 50-feet wide (model cell sizes) which means the properties are effectively an average over an area that wide. It completely misses the potential narrow pathways that could preferentially allow particles to exit the system.

Simulation of mining should be improved by doing the following:

- The actual injection/recovery wells should be simulated, with injection rates depending on the localized conductivity and pressures that would be acceptable for operations.

ADEQ response to Comment #6.34
ADEQ does not agree that simulating individual injection/recovery wells in the groundwater flow model is necessary. As discussed in Excelsior's responses to ADEQ's "Comprehensive Request for Additional Information, Gunnison Copper Project – Individual Aquifer Protection Permit – Inventory No. 511633" dated September 1, 2016, Response to ADEQ Comment #8, the groundwater flow model grid size of 75 square feet in the area of the well field was based upon a geologic interpretation grid of 50 feet by 100 foot. The 75 square foot grid size is approximately equal to the 5-spot injection/recovery well pattern that was approved for mining. Within the 5-spots, injection and recovery is planning on being approximately equal. Based upon this information and the increased uncertainty of hydrogeologic information for a much smaller grid size, ADEQ does not believe decreasing the grid size adds any predictive value. Nor is requiring Excelsior to individually place one injection/recovery well in each individual model cell necessary.

- The model should be discretized into much smaller cells at the mine so that injection/recovery can be simulated more accurately. This could include telescoping the regional model into a much more detailed model at the well field.

ADEQ response to Comment #6.35
ADEQ does not agree with the comment. Please see the response to Comment #6.34 on simulating individual injection/recovery wells.

- The geology/fracture intensity model should be used at a smaller scale to provide more detail of flow paths through the well field.

ADEQ response to Comment #6.36
ADEQ does not agree with the comment. Please see the response to Comment #6.34 on additional uncertainties created to decrease the groundwater flow model grid size..

- The POC wells should be redesigned according to results from the modeling. The flow model should be used with MT3DMS to simulate transport from the well field to the POC wells. Assuming sources emanating from various positions through the well field, the model could simulate a plume that POC wells should be positioned to detect.

Clear Creek should provide figures similar to Figure 20 for other time periods and for other model layers. Simply maintaining a drawdown is insufficient; it is necessary to maintain a hydraulic low point wherein no flow from the well field can escape into the regional flow field.

ADEQ response to Comment #6.37
ADEQ does not agree that the POC wells should be redesigned based upon contaminant transport modeling or that contaminant transport modeling is required. The constituents that are being monitored are conservative, in that they travel at the same velocity as groundwater, therefore use of particle transport is appropriate.

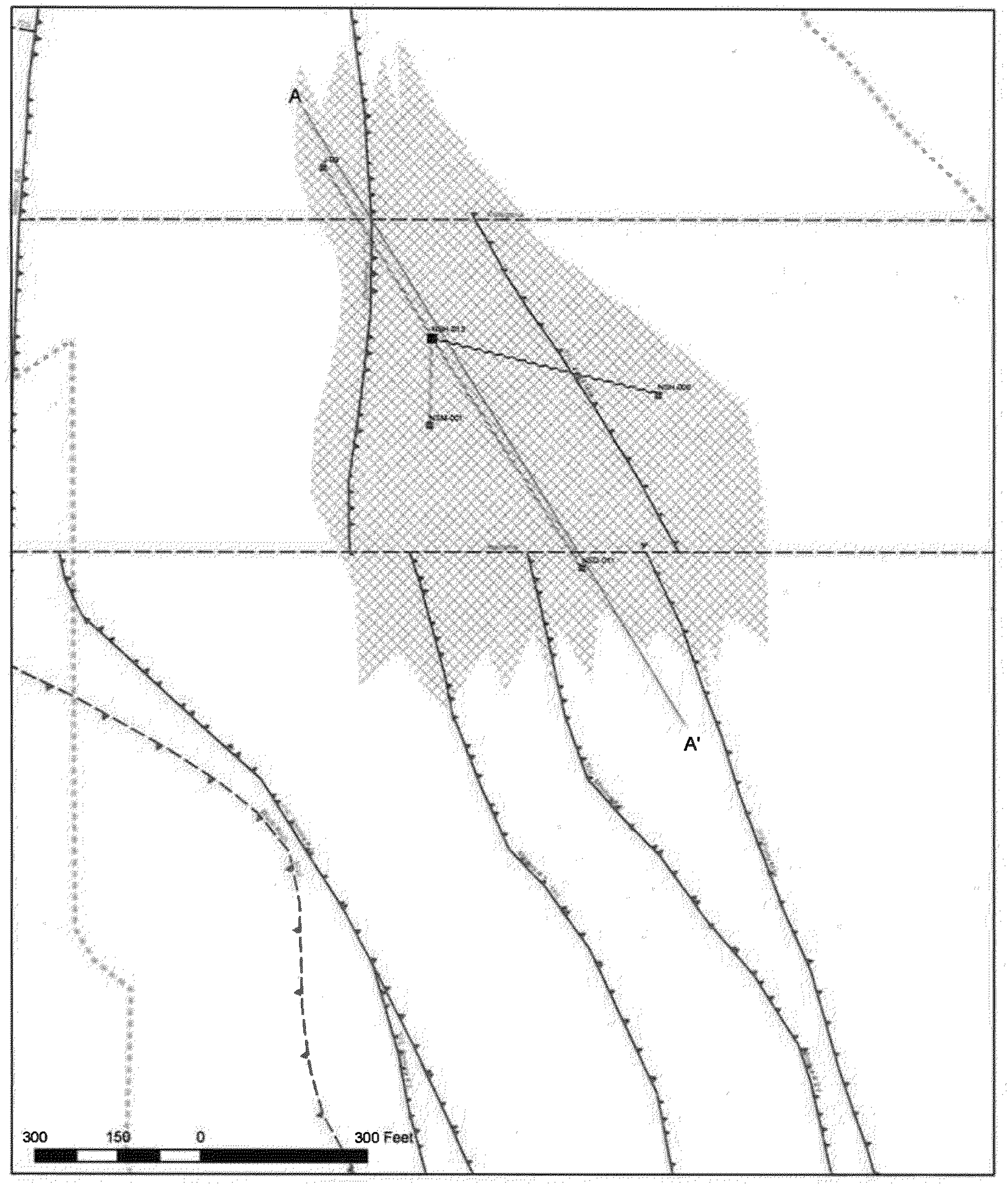
ADEQ does agree that additional water level maps in other model layers may be informative and as stated above in ADEQ response to Comment #5.1, ADEQ is requiring Excelsior to reevaluate and update the groundwater flow model. If during the evaluation, it is determined that evaluating other model layers beside Layer 3 for head and velocity vectors, these figures will be included in the groundwater flow model evaluation and update report.

References

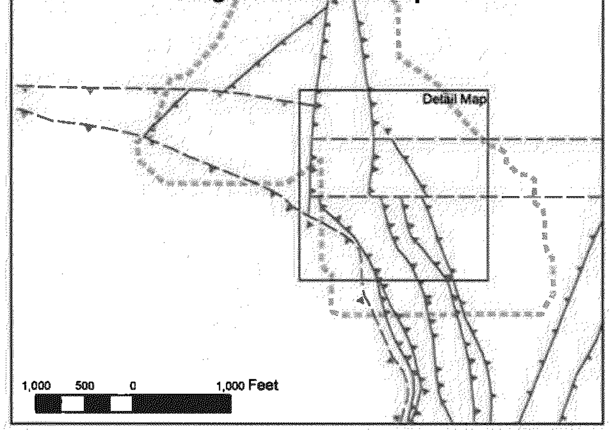
Anderson MA, Woessner WP (1992) Applied Groundwater Modeling, Simulation of Flow and Advective Transport. Academic Press

Clear Creek Associates (CCA) (2016) Aquifer Protection Permit Application, Gunnison Copper Project, Cochise County, Arizona, Prepared for Excelsior Mining Arizona, Inc. Scottsdale AZ

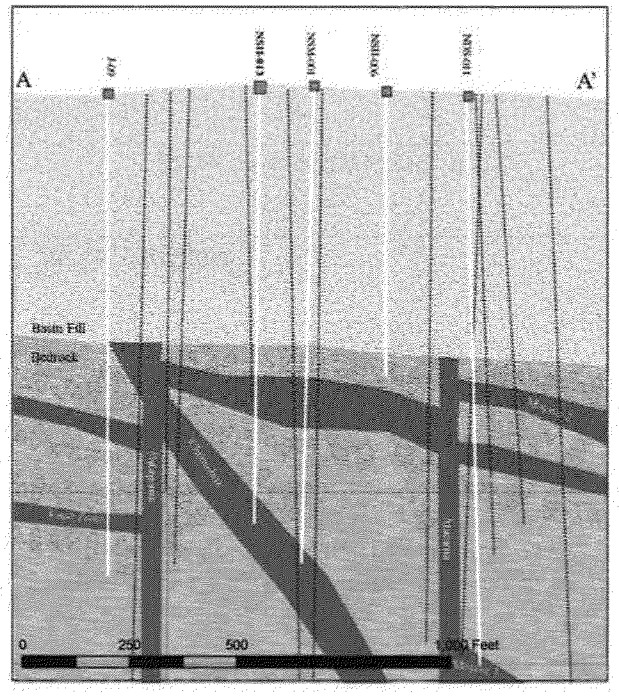
ADEQ Response Figures



Regional Context Map



Cross Section NSH-013: A-A'



Legend

- Observation Well
- Pumping Well
- High Conductivity
- Moderate Conductivity
- Cross Section Line A-A'
- Aquifer Testing Area of Influence
- Approx Fault + Dip Direction (projected at bedrock surface)
- Wellfield Boundary
- Exploration Hole
- Fractured Wallrock

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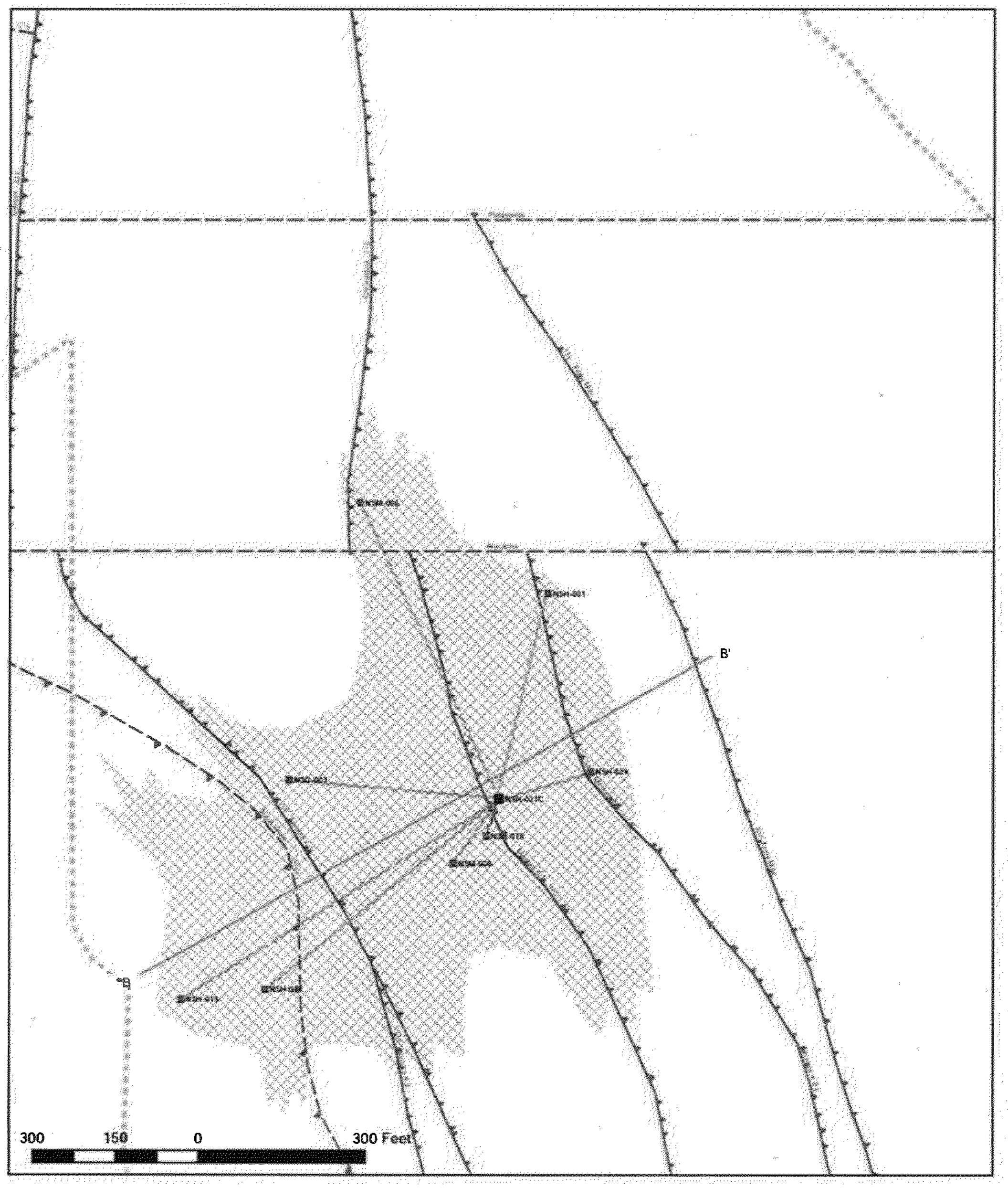
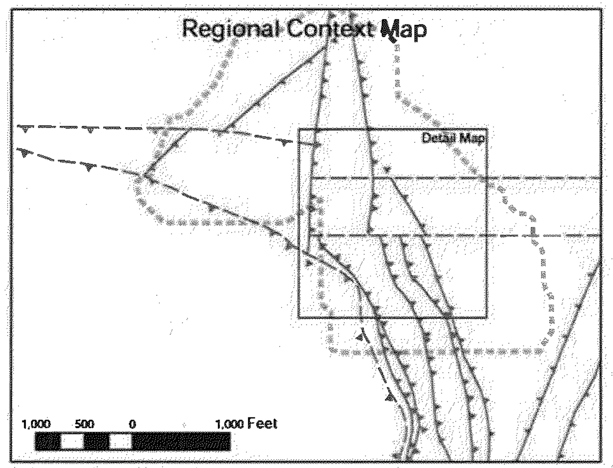
Date Revised: 2/20/2017

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet

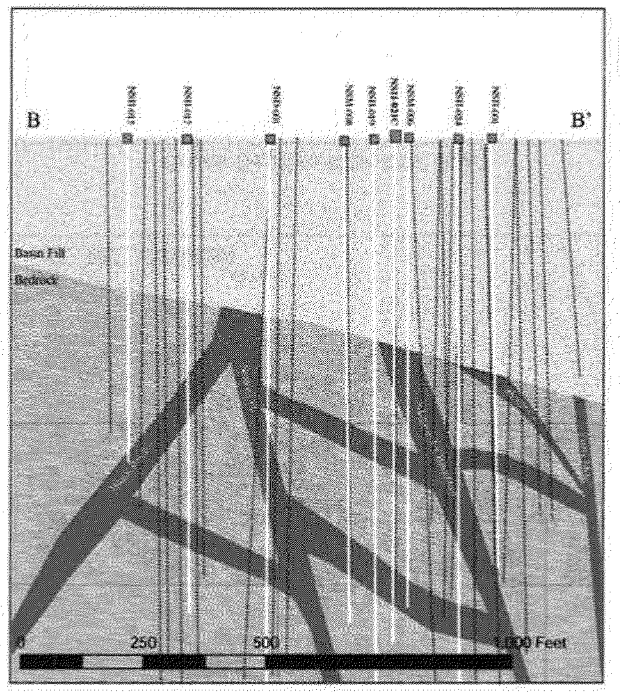
FIGURE 2-1
AQUIFER TESTING AREA OF INFLUENCE NSH-013

ED_001697_00007332-00061





Cross Section NSH-021C: B-B'



Legend

- Pumping Well
- Observation Well
- High Conductivity
- Moderate Conductivity
- Cross Section Line B-B'
- Aquifer Testing Area of Influence
- Approx Fault + Dip Direction (projected at bedrock surface)
- Wellfield Boundary
- Exploration Hole
- Fractured Wallrock

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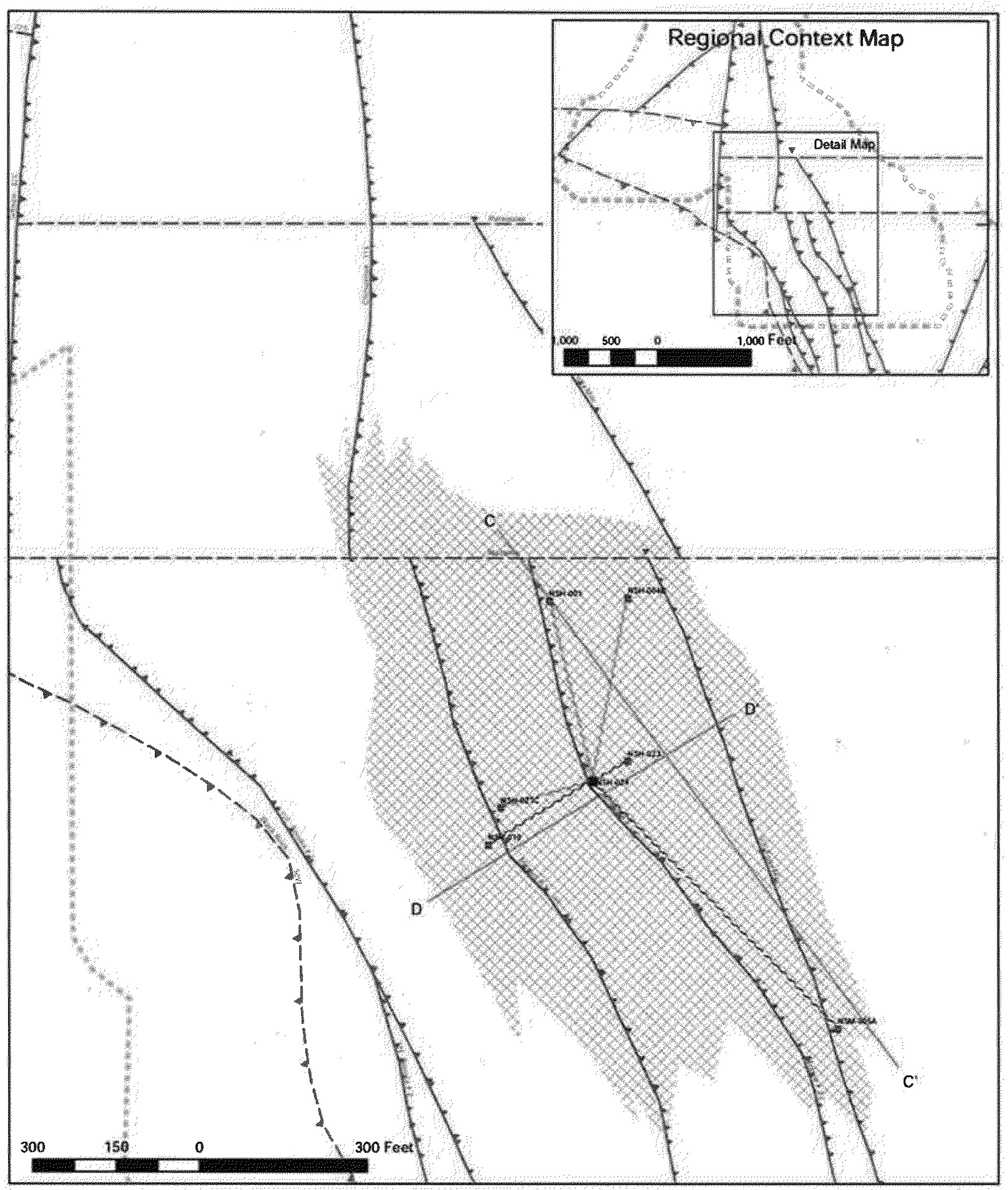
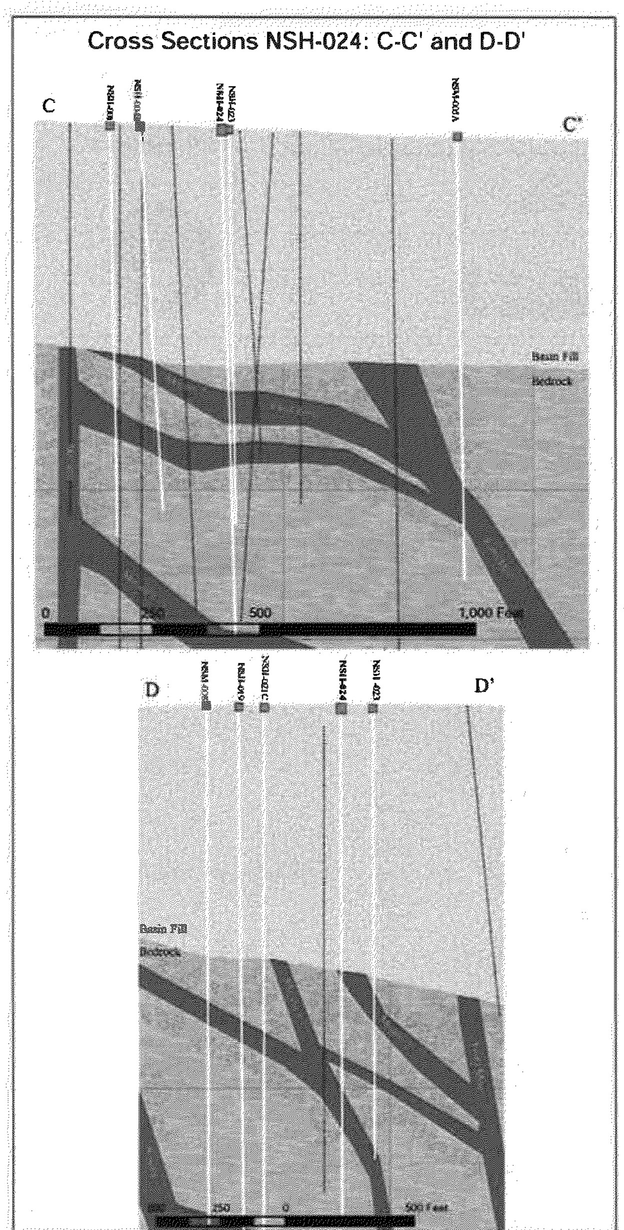
FIGURE 2-2
AQUIFER TESTING AREA OF INFLUENCE
NSH-021C





Legend

- Observation Well
- Pumping Well
- High Flow Strength
- Moderate Flow Strength
- Cross Section Lines C-C' and D-D'
- Section24Labels
- Aquifer Testing Area of Influence
- Approx Fault + Dip Direction (projected at bedrock surface)
- Wellfield Boundary
- Exploration Hole
- Fractured Wallrock

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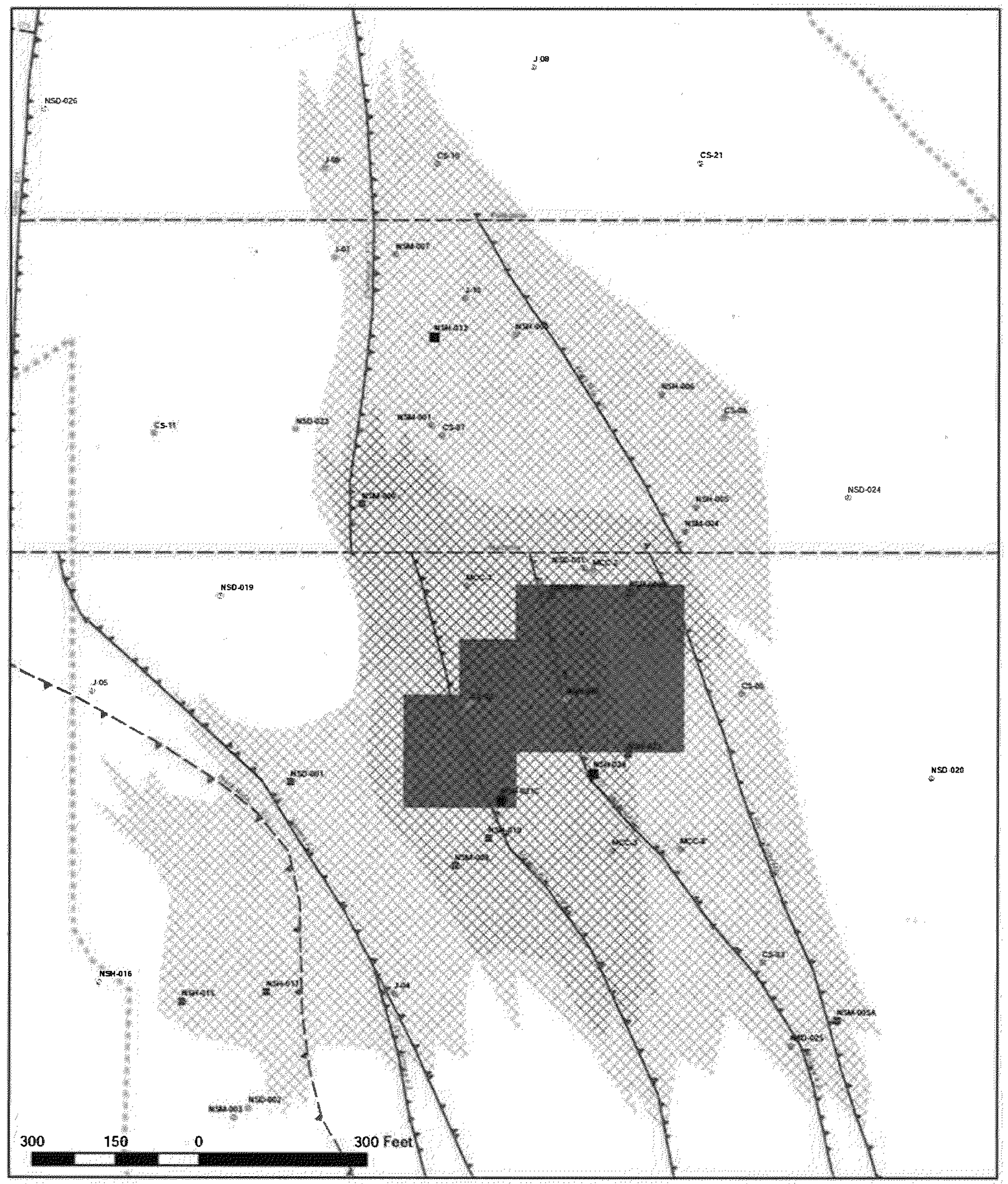
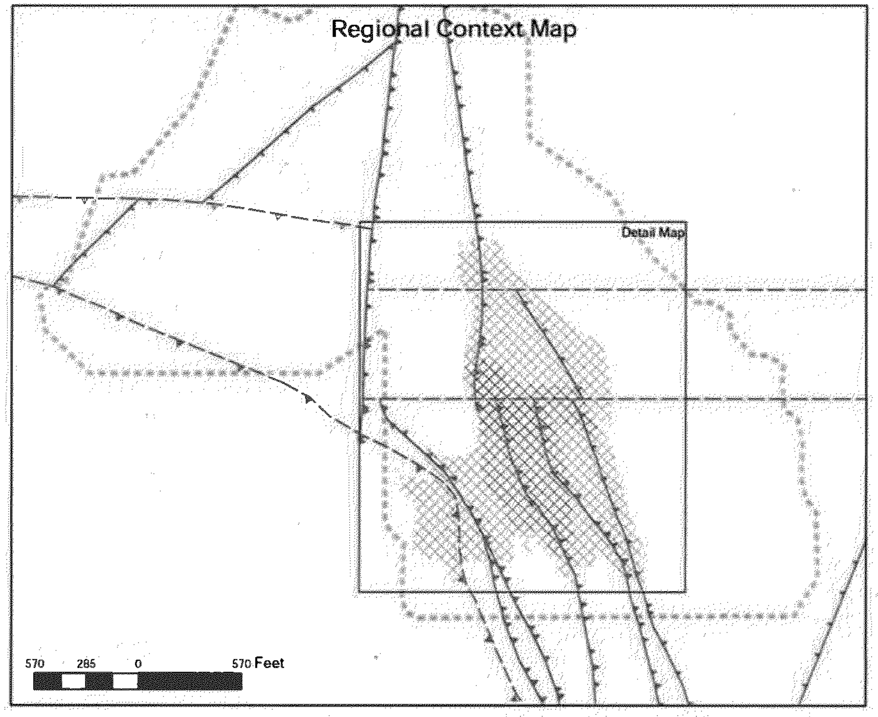
Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet

FIGURE 2-3
AQUIFER TESTING AREA OF INFLUENCE
NSH-024





Legend

- Exploration Hole
- Observation Well
- Pumping Well
- Approx Fault + Dip Direction (projected at bedrock surface)
- Wellfield Boundary
- Aquifer Testing Area of Influence

Production

- Year 1

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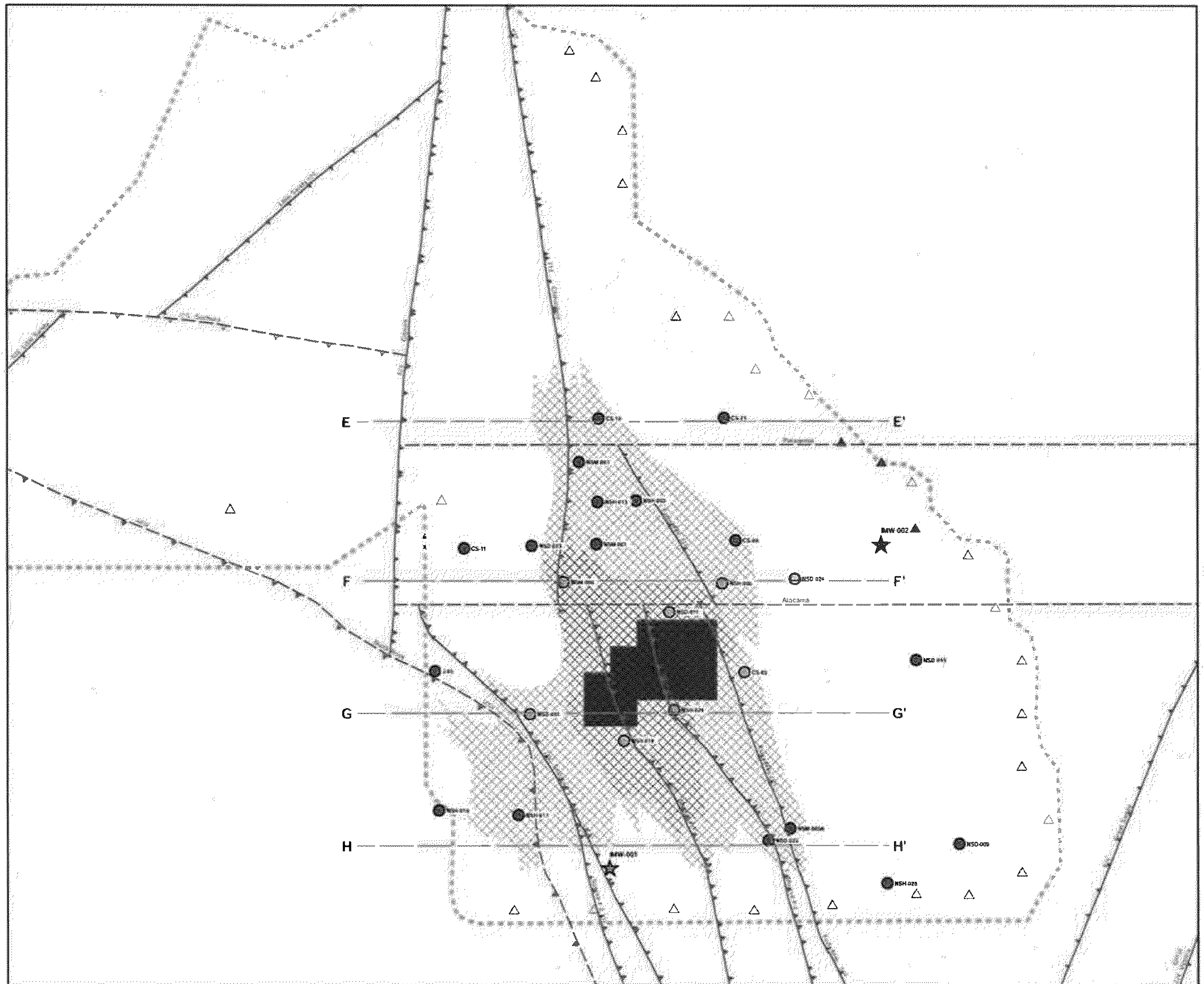
Coordinate System:
NAD 1983
StatePlane Arizona
East FIPS 0201
Feet

FIGURE 2-4
AQUIFER TESTING TOTAL AREA OF INFLUENCE:
NSH-013, NSH-021C, NSH-024

ED_001697_00007332-00064



Legend

Approx Fault + Dip Direction (projected at bedrock surface)

Cross Section Lines E - H

New IMW

Outer IMW

Inner IMW

Active HC Wells

Inactive HC Wells

Aquifer Test Influence Area

Wellfield Boundary

Production

Year 1

370 185 0 370 Feet

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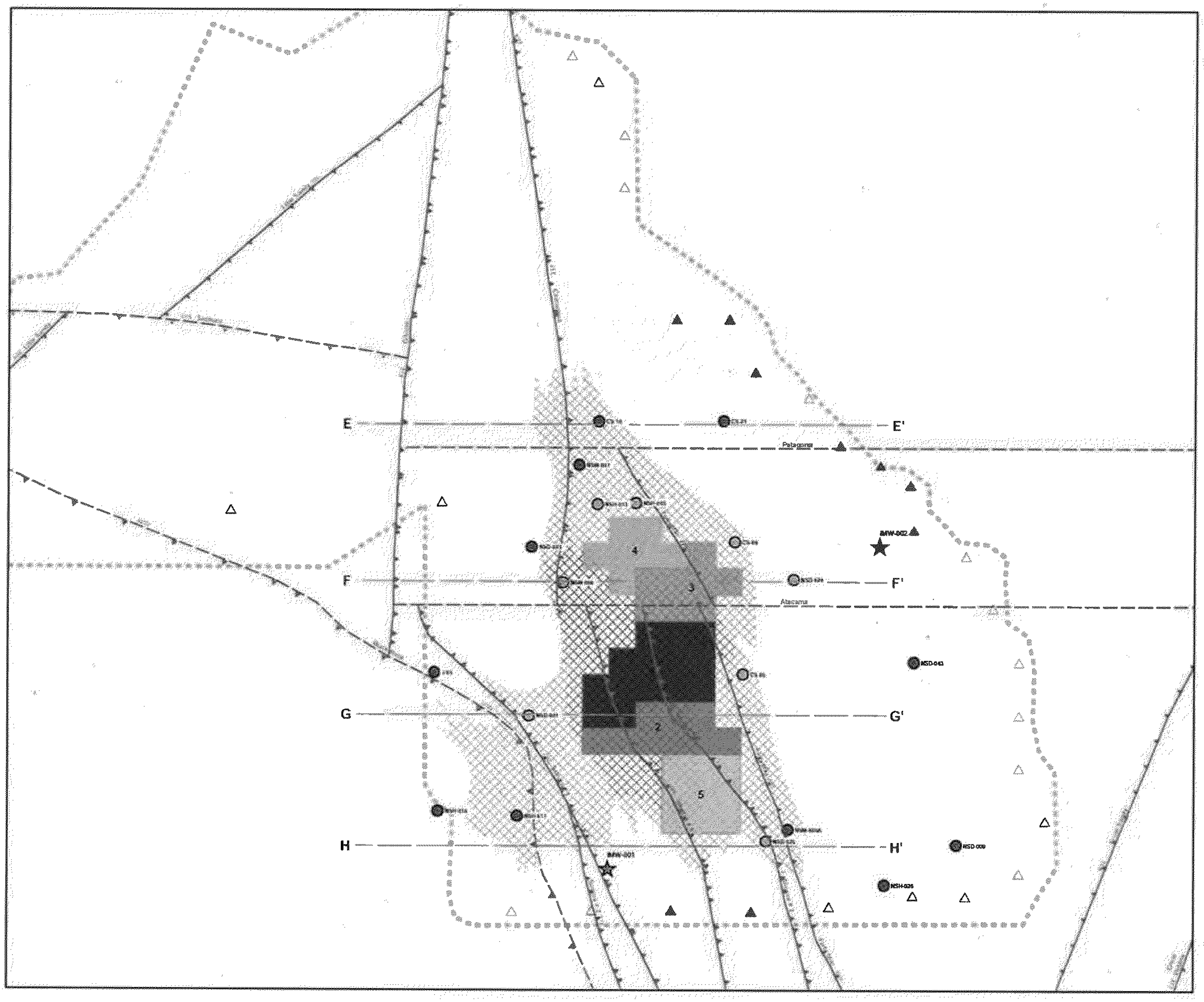
Date: 2/20/2017

N

Coordinate System: NAD 1983
StatePlane Arizona East FIPS 0201
Feet

FIGURE 2-5
INTERMEDIATE MONITORING WELL LOCATIONS: YEAR 1



Legend

- Approx Fault + Dip Direction (projected at bedrock surface)
- Cross Section Lines E - H
- New IMW
- Active HC Wells
- Inactive HC Wells
- Outer IMW
- Inner IMW
- Aquifer Test Influence Area
- Wellfield Boundary

Production

- Year 1
- Year 2
- Year 3
- Year 4
- Year 5

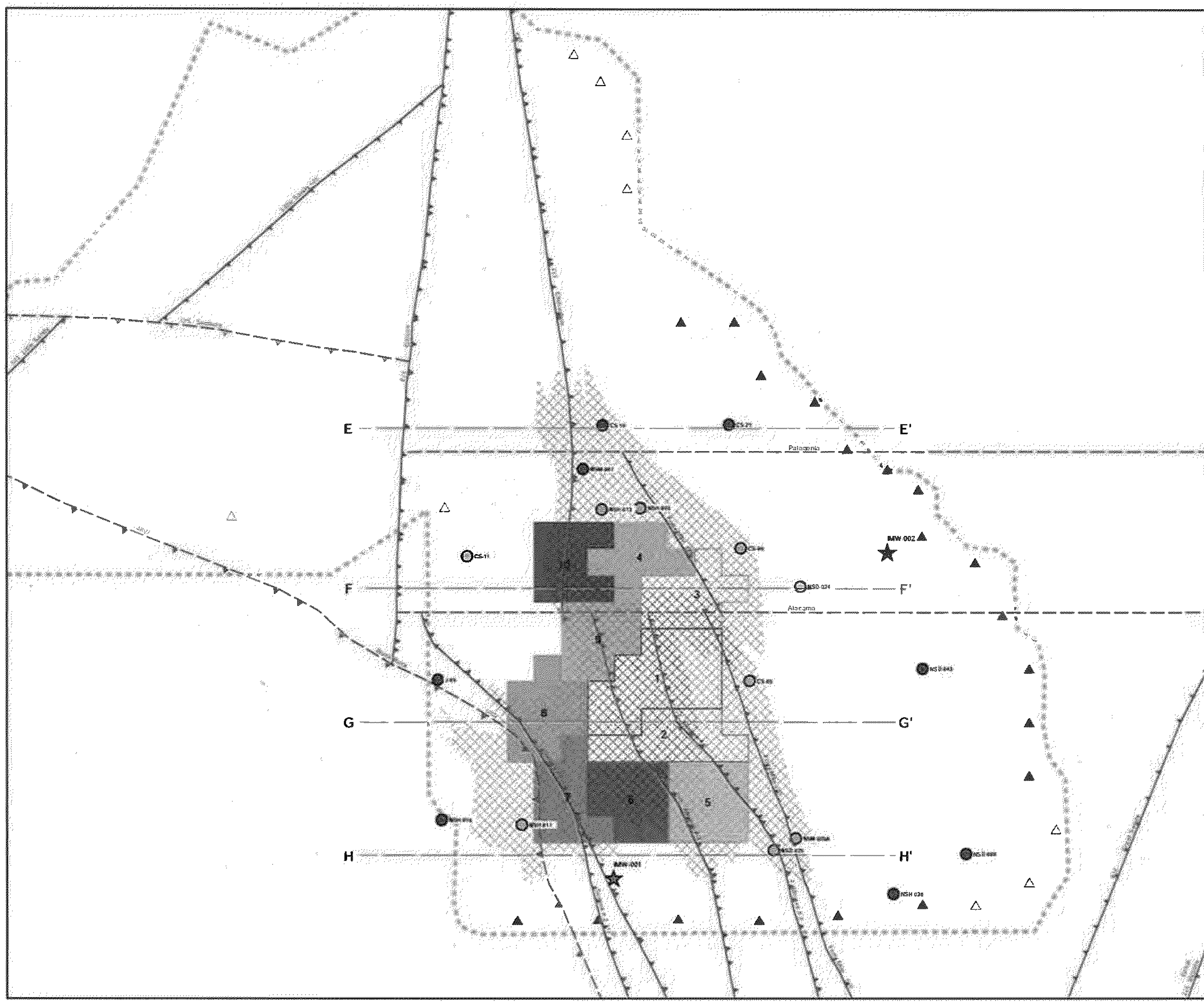
370 185 0 370 Feet

Excelsior MINING CORP

Excelsior Mining Arizona Inc.
Gunnison Copper Project
Date: 2/20/2017

Coordinate System: NAD 1983
StatePlane Arizona East FIPS 0201
Feet

FIGURE 2-6
INTERMEDIATE MONITORING WELL LOCATIONS: YEAR 5



Legend

Approx Fault + Dip Direction (projected at bedrock surface)
Cross Section Lines E - H
New IMW
Outer IMW
Inner IMW
Active HC Wells
Inactive HC Wells
Aquifer Test Influence Area
Wellfield Boundary

Production
Year 1 (Rinsed)
Year 2 (Rinsed)
Year 3 (Rinsed)
Year 4
Year 5
Year 6
Year 7
Year 8
Year 9
Year 10

370 185 0 370 Feet

Excelsior MINING CORP

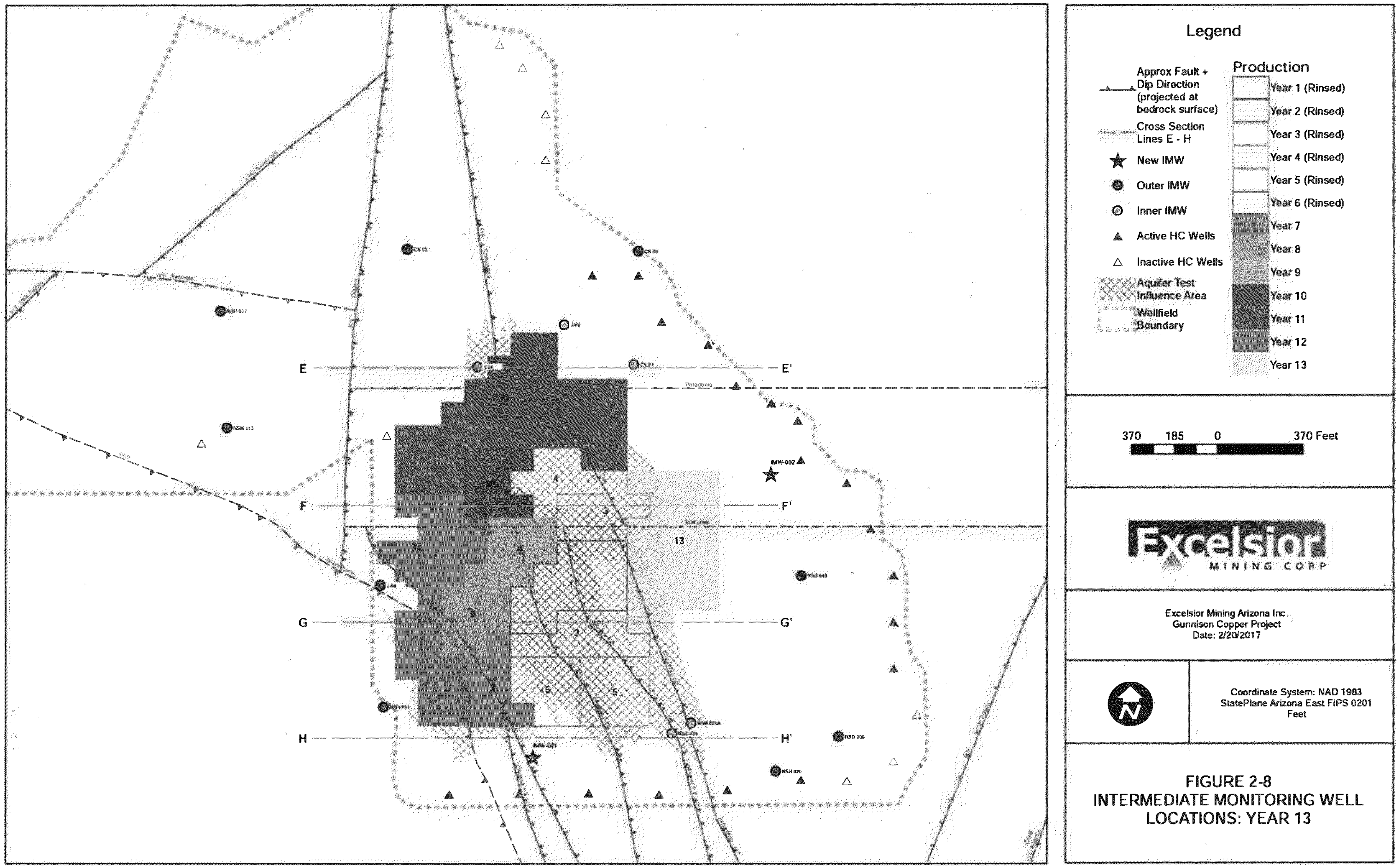
Excelsior Mining Arizona Inc.
Gunnison Copper Project
Date: 2/20/2017

N

Coordinate System: NAD 1983
StatePlane Arizona East FIPS 0201
Feet

FIGURE 2-7
INTERMEDIATE MONITORING WELL LOCATIONS: YEAR 10

ED_001697_00007332-00067



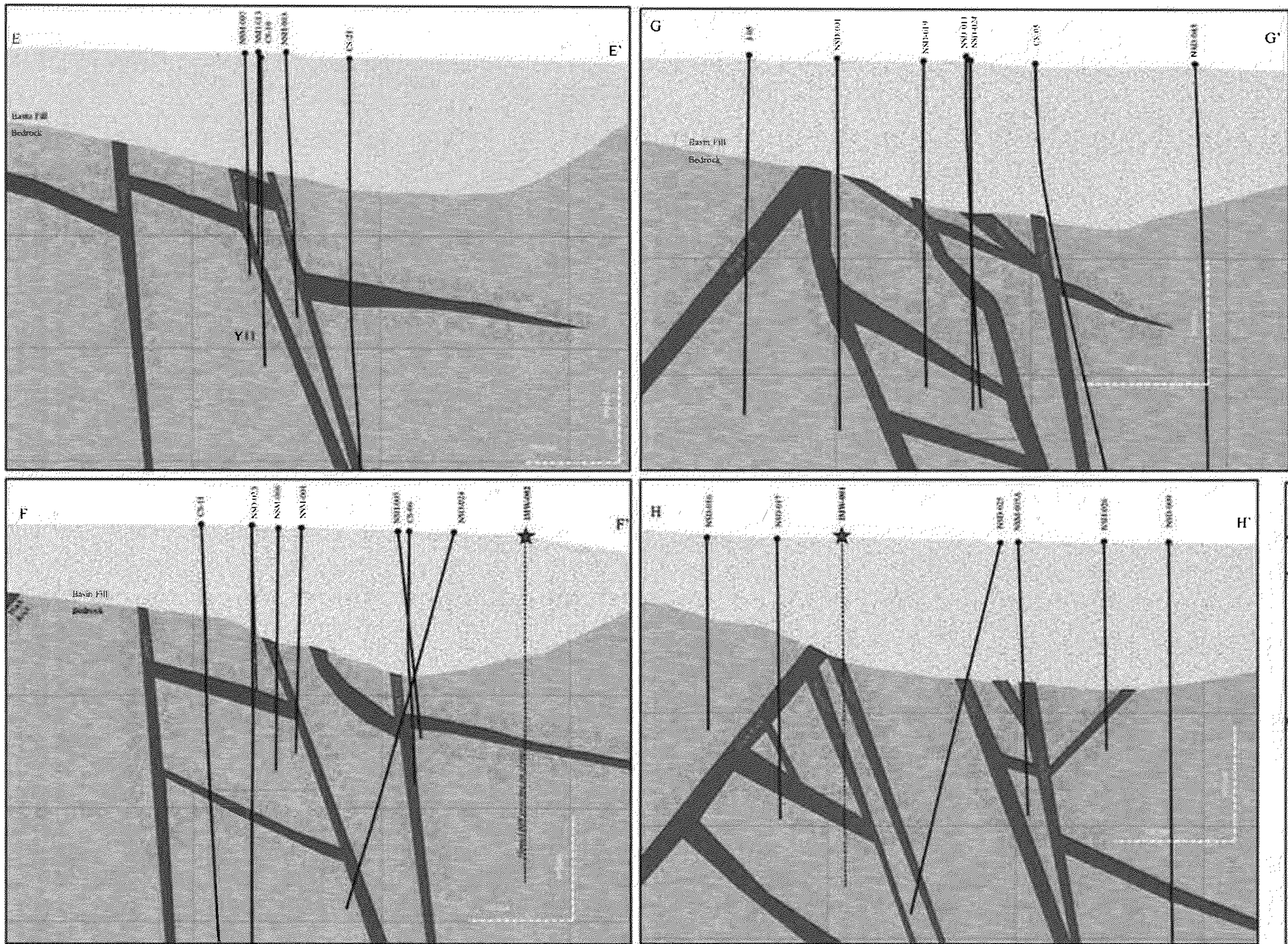
Excelsior MINING CORP

Excelsior Mining Arizona Inc.
Gunnison Copper Project
Date: 2/20/2017

Coordinate System: NAD 1983
StatePlane Arizona East FIPS 0201
Feet

FIGURE 2-8
INTERMEDIATE MONITORING WELL
LOCATIONS: YEAR 13

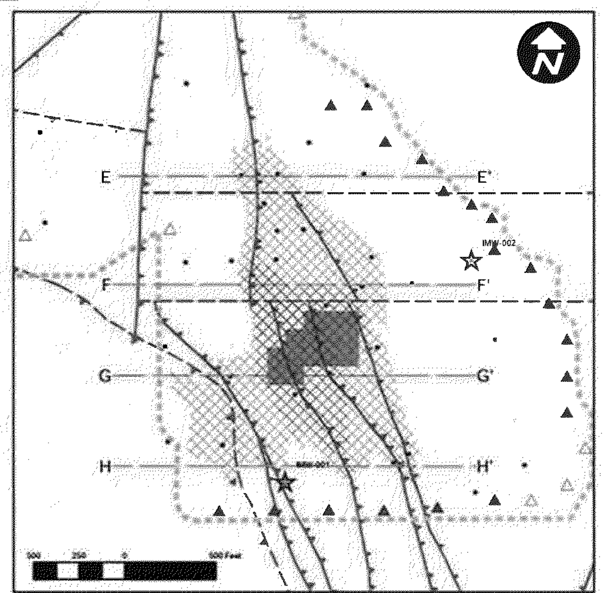
ED_001697_00007332-00068



Excelsior MINING CORP

Excelsior Mining Arizona Inc.
Gunnison Copper Project
Date Revised: 2/20/2017

Coordinate System: NAD 1983 StatePlane
Arizona East FIPS 0201 Feet



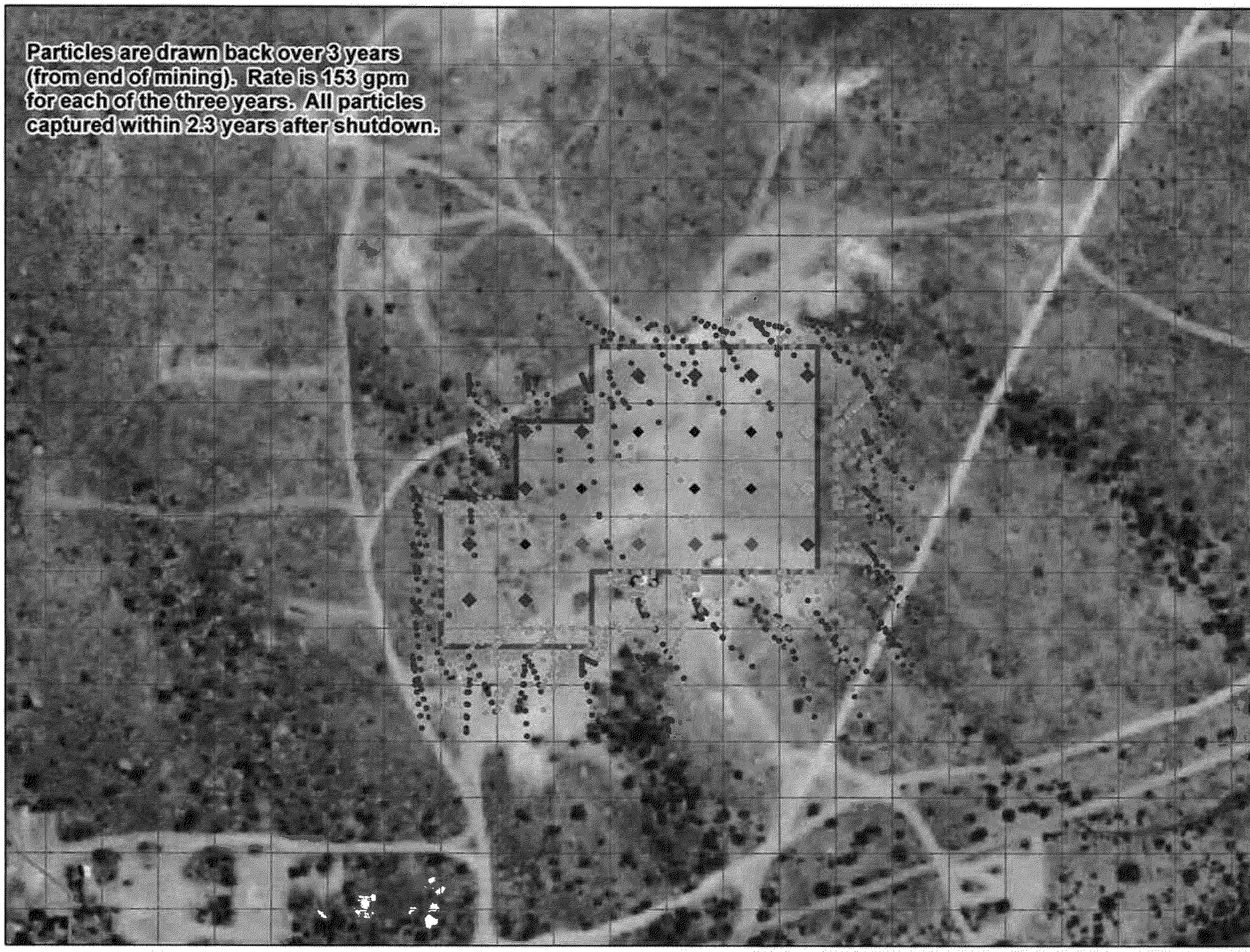
Legend

- New IMW
- IMW
- Pump Test Influence
- Wellfield Boundary
- Cross Section Lines E - H
- Active HC Wells
- Inactive HC Wells
- Approx Fault + Dip Direction (Faults projected at bedrock surface)
- Production
- Year 1
- Overburden
- Bedrock
- Fault Zone
- Fractured Bedrock
- IMW
- New IMW

FIGURE 2-9
INTERMEDIATE MONITORING WELL LOCATIONS - CROSS SECTIONS E-F

ED_001697_00007332-00069

Particles placed at beginning and end of mining period
(1 day and 365 days) in center of adjoiniing model cell.
PRELIMINARY DRAFT
Explanation
Initial Particle Placement
Wells Simulated
(gpm)
0
3
10
20
Model Grid
Year 1 83
Wellfield
0
100
200
Feet
Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
February 2017
Date
2/20/17
File ID
373002
N
CLEAR CREEK ASSOCIATES
FIGURE 8-2
Closure Strategy
Particles and Well Rates
Mining Year 1



Explanation

Particle Traces
(days)

- 1 - 365
- 366 - 730
- 731 - 1095
- 1096 - 1460

Wells Simulated
(gpm)

- 0
- 3
- 10
- 20

Model Grid

Year 1 Block

Wellfield

Note:
Particle tracks simulated reflect the regional flow field with no attampt to contol migration. Because the proposed contol strategies involve pullback while operating, this simulation is considered very conservative.

0 100 200
Feet

Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
February 2017

Date	File ID
2/21/17	373002

N

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FIGURE 8-3
Closure Strategy
Containment after Shutdown
Mining Year 1


Explanation
HC Wells for Year 5
Status
Inactive
Active Year 5
Stage 1 Permit Wells
YEAR
1
2
3
4
5
Model Grid
Year 1 83
Year 2 83
Year 3 83
Year 4 83
Year 5 83
Wellfield
0 100 200
Feet
Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
February 2017
Date
2/19/17
File ID
373002
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FIGURE 8-4
Closure Strategy
Pumping Rates for Wells
Mining Year 5 Closure

FIGURE 8-5
Closure Strategy
Drawdown after Year 8
Mining Year 5 Closure

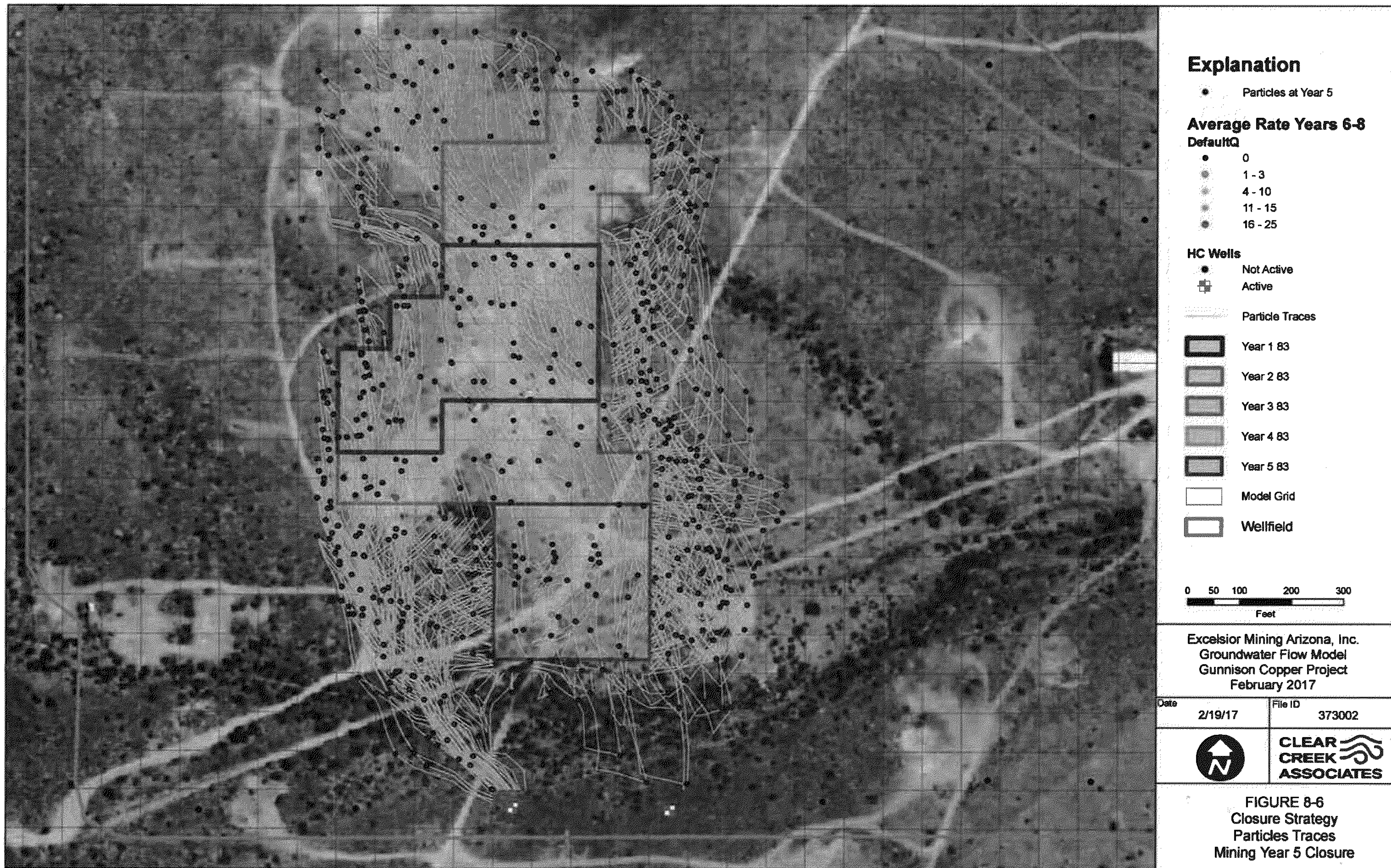
Explanation
Particles at Year 5
Average Rate Years 6-8
DefaultQ
0
1 - 3
4 - 10
11 - 15
16 - 25
HC Wells
Not Active
Active
Particle Traces
Year 1 83
Year 2 83
Year 3 83
Year 4 83
Year 5 83
Model Grid
Wellfield
0 50 100 200 300
Feet
Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
February 2017
Date
2/19/17
File ID
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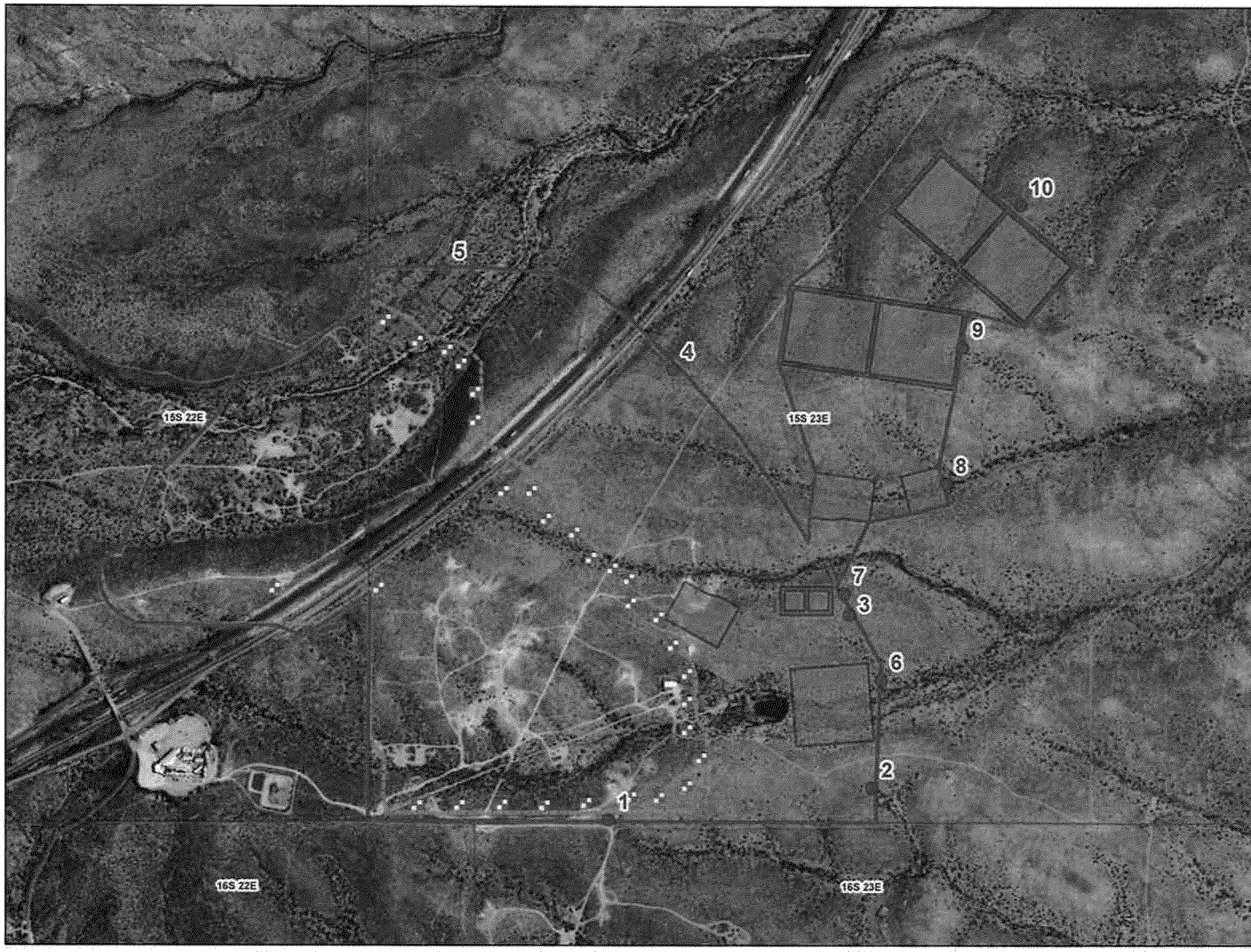
FIGURE 8-6
Closure Strategy
Particles Traces
Mining Year 5 Closure



Explanation

- Hydraulic Control Wells
- POCs
- PMA and DIA Boundary
- Pond Locations
- Wellfield
- Township

0 250 500 1,000 1,500
Feet

Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
February 2017

Date	File ID
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FIGURE 9-1
Discharge Impact Area and PMA Boundary